



Northumberland College

Saddle Up: An Investigation into the Occurrence of Saddle Slip in Mounted Games
Ponies

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DECLARATION

This project is a product of my own work
and is not the work of any collaboration.

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ABSTRACT

Correct saddle fit is essential to the ridden horse-rider relationship, and as noted by a number of studies has a paucity of quantitative research available. Mounted Games is a discipline involving speed, accuracy, fast turns, scoops and vaulting - all at a gallop. It can be assumed visually from watching these competitions that there are incidences of saddle slip, however there is no existing research to prove or disprove this suggestion. The objective of this study is to prove or disprove the occurrence of saddle slip in Mounted Games ponies throughout various Mounted Games movements.

Throughout this study, reviews of the causes and concepts of saddle slip, the detrimental effects to the horse and rider combination, and the potential for future research will take place, alongside the comparison of this information to the hypotheses, experimental design and data collection.

Three ponies used for both Mounted Games competition and training were tested during a control movement, the vault, the scoop and the standing corner vault. Data was collected using motion capture and analysed through biomechanics software to determine the degree of saddle slip. The results found that saddle slip in both the scoop ($p = <0.001$) and the vault ($p = 0.034$) was significant, presenting conclusions that consistency between the two movements varied, with more consistency seen in increases of saddle slip during the scoop. The highest degree of saddle slip was seen during the stance phase of the stride cycle, leading to inferences that there is not just rider influence intensifying the slip of the saddle.

Further expansions of this study are needed in future, to determine the occurrence of saddle slip through a larger sample size, and to deduce the negative impact this can have on Mounted Games ponies through excessive pressure points and biomechanical compensations. Collaboratively, this research would then be able to

form a comprehensive account of how improve Mounted Games and pony welfare can be greatly improved, as well as minimal gains in competition performance.

INTRODUCTION

Whilst attending the Horse of the Year Show in the early 1950's, HRH Prince Philip devised an event for children where they could enjoy amateur mounted competition without the need to own expensive show horses. In 1957, they held the first Mounted Games Championships at HOYS and the Prince Philip Cup competition was born. Following this, Norman Patrick founded the Mounted Games Association of Great Britain in 1984, which was initially based at his home address in Surrey. As more riders joined the association, it progressed to become a limited company, and now includes riders around the world as part of the International Mounted Games Association. With races involving speed, accuracy, fast turns, and vaulting - all at a gallop - mounted games have quickly become one of the most exciting competitions on horseback (MGAGB, 2020).



Plate 1: A rider performing the vault at a gallop during Mounted Games Competition
(Alexander, 2020)

During locomotion and ridden activity, despite correct fitting, saddles can displace both dorsolaterally and craniocaudally. Correct saddle fit is essential to the ridden horse-rider relationship, and when determining the reasons why saddle displacement occurs, additional factors need to be considered including equine

laterality, horse and rider asymmetries and saddle construction (MacKechnie-Guire *et al*, 2018a). As research develops, it has become apparent that saddles which are fitted incorrectly or are displacing can have a negative effect on both ridden performance and the welfare of the horse (Bondi *et al*, 2020), with a large number of saddles in the ridden horse population not fitting correctly (Dyson *et al*, 2020). Studies completed since 2006 have shown that a concentrated distribution of pressure under saddle negatively affects thoracolumbar locomotion and the hind limb gait, as well as asymmetrical force distribution and loading on the horse's limbs (de Cocq *et al*, 2006; Meschan *et al*, 2007; Kotschwar *et al*, 2010; von Peinen *et al*, 2010; Greve *et al*, 2015; Dyson *et al*, 2020; Roost *et al*, 2020). Understanding and acting on the causes of why saddle displacement takes place has the ability to boost muscular performance and lessen the occurrence of thoracolumbar dysfunction and poor performance, thus providing opportunities for marginal gains in competition (MacKechnie-Guire *et al*, 2018a; 2019).

It has been suggested in more recent studies, that average saddle pressure values of >11 kPa are detrimental to the thoracolumbar movement of horses (Byström *et al*, 2010; Greve *et al* 2015; MacKechnie-Guire *et al*, 2018a). During locomotion, the forces absorbed by the horse's back varies between gaits; in walk the force is equivalent to the bodyweight of the rider- these increase to twice the bodyweight in trot, and 2.5 times rider bodyweight in canter (Fruehwirth *et al*, 2004; MacKechnie-Guire, 2020). Even with no rider, the forces acting on the back under saddle can reach between 200 and 300 Newtons in walk and trot, and increased areas of peak pressure are normally noted around T12/T13 in the area where the points of the tree sit. The *m. longissimus dorsi* muscle in this area is responsible for the stabilization of the vertebral column against dynamic forces, applied as part of the horse-saddle-rider interaction it helps prevent injury to the locomotive system, maintaining the significant requirement of a strong and healthy equine

musculoskeletal system (MacKechnie-Guire *et al*, 2018a; MacKechnie-Guire *et al*, 2018b).

The *m. longissimus dorsi* muscle, which lies directly below the saddle in the thoracic region, moves dorsoventrally, mediolaterally, and craniocaudally, but also rotates axially with lateral bending and flexion and extension during locomotion (MacKechnie-Guire *et al*, 2018a). This area regulates posture and movement control during locomotion, and it has been hypothesized that this muscular ability to stabilise the spinal region and produce force can limit manoeuvrability during tighter turns due to the danger of slipping (Tan & Wilson, 2010); this is because of the horse's natural ethology to remove itself during encounters with potential predators, the ability to turn a tight radius at high speed is essential to remove itself from the situation. Tight, high speed turns are regularly required during mounted games to collect objects, and to finish the race in the fastest time possible. It has been suggested (Pfau *et al*, 2012; Starke *et al*, 2012; Brocklehurst *et al*, 2014), that when compared to movements in a straight line in trot, turning has the potential to introduce changes to the symmetrical gait due to body lean – thus making the horse's movement compensate asymmetrically. Asymmetries in trot movement of the diagonal pairs of limbs has been shown to have significant effects on contralateral limb loading and the rotational movements of the dorsal spine and thoracolumbar region of the horse (MacKechnie-Guire *et al*, 2018a). Being able to quantify these changes with visual indicators and gait analysis allows us to have greater insight into the effects of ridden work on horses and aid in the promotion of better working conditions and welfare standards in the industry (Pfau *et al*, 2015).

There has been an increase in public interest around the capitalisation of horses and related welfare concerns in the equine industry, with social license to operate (SLO) becoming a trend - an unwritten and non-binding contract with members of

the general public based around the trust, legitimacy, communication and transparency of industries (Duncan *et al*, 2018; Ashton, 2020). It is suggested that there is an obligation to prevent harm to horses through training, handling and management practices, which often result in what is known as utilitarianism and “acceptable harms”, an ethical theory which trades damage to horse welfare standards for benefits to humankind (Piacquadio, 2017; Faulhaber *et al*, 2018). It is important to understand that every action which is performed during the interaction with horses has a consequence, either positively or negatively, to horse welfare (Duncan *et al*, 2018). Jonsson (2012) believes that the use of horses in modern society is justified through the alternative possibility being their non-existence. By being able to justify our actions through the four lenses of the SLO - Trust, Legitimacy, Communication and Transparency - it can be ensured that the reasons behind our actions are sufficient for the welfare of the horse and have a positive effect on its ability to function normally both physiologically and psychologically (McGreevy *et al*, 2017).

In the following sections, current research will be reviewed, including the causes and concepts of saddle slip, the detrimental effects to the horse and rider combination, and potential for future research. Through evaluation and experimentation, the occurrence of saddle slip in mounted games will either support the null (H_0) hypothesis that there will be no significant saddle slip during movements or support the hypothesis (H_1) that there will be significant saddle slip.

By assessing the outcome of the hypothesis, the probable effects of saddle slip on mounted games ponies can be determined, the welfare consequences and the potential for future research to improve training and competitive conditions for mounted games ponies across the world.

LITERATURE REVIEW

Saddle Slip and Fit

In 2015 Clayton *et al* stated that industry currently knows more about the horse-saddle-rider relationship and saddle slip than ever thanks to current research, but there is still a significant number of questions which still do not have conclusive answers. MacKechnie-Guire often references a paucity of quantitative research relevant to saddle fit, its causes and its effect (2018a; 2020). Almost all of the current knowledge which has been accumulated in the past 5 years is largely based on practical, clinical understanding, but there is the need to carry out many more quantitative studies if research is to be successfully evaluated in order to make advances in welfare and scientific developments (Byström *et al*, 2018). The research discussed, unless stated otherwise, is carried out using studies on elite riders and sport horses, none of which has been aimed at the amateur or everyday competition rider.

2.1 Saddle Fit

It is imperative during saddle fitting to ensure the correct fit both statically and dynamically, as a well fitted saddle should show very minimal signs of dorsolateral or craniocaudal displacement and should remain in balance with the horse during both ridden and non-ridden work (Dyson *et al*, 2015; MacKechnie-Guire *et al*, 2018a). An ill-fitting saddle has the opportunity to have a negative impact on the biomechanics of the thoracolumbar region and has been seen to induce muscular atrophy during the muscular development of the dorsal area of the thoracic spine (von Peinen *et al*, 2010; Greve *et al*, 2015). A small amount of dorsolateral movement in the saddle during ridden work is normal, however the seat should remain parallel to the ground, with the balanced rider sitting centrally on the tree (Dyson *et al*, 2015). Despite correct saddle fit, saddle displacement has still been seen to occur laterally. By considering external factors of saddle fit such as equine laterality, asymmetries, conformation and saddle construction there may be

opportunities which would enable us to more successfully quantify why saddle displacement occurs in correctly fitted saddles (MacKechnie-Guire *et al*, 2018a).

Studies incorporating asymmetrical saddle movement patterns in horses have been seen to produce hair rubbing in asymmetrical patterns which would suggest that there is an exertion of asymmetrical forces over the horses back (Gunst *et al*, 2019). Uneven saddle pressure distribution is usually blamed on ill-fitting saddles; however, there is a need to consider the multifactorial approach of the rider influence on asymmetries regardless of fit. The 2019 study provided by Gunst *et al* suggested that before any asymmetric pressure patterns in the dorsal musculature area is blamed on ill-fitting saddles, all external factors need to be considered; they showed that unlike horses, saddles are unable to compensate for asymmetrical loading of force created by the rider, with the rider's weight distribution determining how freely a horse can move underneath them (Fruehwirth *et al*, 2010). With this information, MacKechnie-Guire *et al* (2018) harmonised this research, stating that to correctly optimize the horse-rider connection, correct saddle fit, and saddle fitting procedures are essential and in 2019 they then suggested that enhanced athletic performance of both the horse and rider can be directly correlated to correct saddle fit.

2.2 Saddle Slip

Byström *et al* (2018) proposed that saddle slip is the gradual shift of the saddle from the midline of the thoracic region during ridden exercise.

It has been previously suggested by Clayton *et al* (2015) that horses showing signs of hindlimb lameness are up to 52 times more likely to experience saddle slip than those who showed no signs of lameness. Byström *et al* independently verified this information in their 2018 research, stating that hind limb lameness interaction with certain factors was found to cause saddle slip. However, they argued that both

rider asymmetries, lameness and saddle fit were all found to be independently responsible for saddle slip cases in both lame and non-lame horses. In 2020, research found that when associated with subclinical hindlimb lameness, saddle slip was noticeable during non-ridden lunging work and in hand trotting (Roost *et al*, 2020). Bondi *et al* (2020) also explored this thought, with their research suggesting that consistent saddle slip to one side is most likely caused by hindlimb lameness, although this lameness could be bilateral, subclinical or low grade which would make clinical detection difficult (Greve & Dyson, 2013; 2014). All of this exploration strengthens the current industry belief that the horse-rider-saddle interaction is significantly more important than the independent movements of the horse and rider alone (Byström *et al*, 2018).

2.3 Kinematics

There is a large number of equestrian disciplines and activities which require horses to perform turns at high speed (Brocklehurst *et al*, 2014), including those taking part in mounted games competition or training. When performing these movements, horses create ground reaction forces (GRF) during the stance phase of the stride cycle which provides the centripetal acceleration needed to move on a circular path rather than using inertia on a straight line. This research by Brocklehurst *et al* (2014) has shown that during the trot, turning movements can create systematic changes to head and trunk symmetry in the horse as it leans toward the centre of the turn. Backed up by strong historical research (Chateau *et al*, 2013; Clayton and Sha, 2006; Hildebrand, 1965; Hobbs *et al*, 2011; Pfau *et al*, 2012; Starke *et al*, 2012; Walker *et al*, 2012), they were able to establish that the lean is created to counteract the potential of collapsing into the centre of mass, and the alignment of all four limbs becomes directed towards the ground reaction force. In 2006, Clayton and Sha produced a study which suggested that the direction of turn can change the degree of lean and asymmetry that the horse creates, connecting this to variations in horse strength, suppleness and neural

programming. This data was then reinforced in 2012 by Pfau *et al*, who suggested that the size of centripetal acceleration created by a horse depends on both the velocity and size of the turn because of the acceleration needed to move through the turn. Tan and Wilson (2010) suggest that this is because a crucial ability for undomesticated horses is the capability to change direction at speed during predatory encounters. During tighter turns, constraints such as the potential of slipping can limit horse manoeuvrability, meaning that at a smaller radius and higher speed, the body lean needed by the horse increases and would potentially create compensatory asymmetric movements during trot.



Figure 1: Diagram showing the direction of force and the body lean needed by the horse.

The vertical arrow shows the force of gravity, and the L shape axis shows the force of centripetal acceleration. (Tan and Wilson, 2010)

Throughout locomotion, both ridden and non-ridden, both three-dimensional translations and rotations occur in the horse's thoracic region where the saddle sits centrally (MacKechnie-Guire *et al*, 2018). This area of the back has the most muscle activity which relates to movement control and the stabilisation of spinal movement. Studies by Murray *et al* (2017; Greve *et al*, 2015) showed that saddle fit influenced variations in equine back shapes beneath the saddle over the T13 region and found that repeatable areas of peak saddle pressures at consistent

stages of the stride cycle also occurred in this area. They suggested that this could be caused by the three planes the equine back moves through, including lateral bending, axial rotation and flexion/extension. All three of these planes would hold the potential to negatively, or positively, alter saddle pressures. Maximal back flexion is seen to occur during the swing phase of the stride cycle, however maximal extension is seen during the stance phase of trot on load bearing limbs (Audigie *et al*, 1999; Clayton, 2012; Robert *et al*, 2002). Research has shown that the equine back is not static in shape, Dyson *et al* (2015) suggested that exercise can cause variations in the dimensions of the back, under the presumption that the saddle is fitted correctly. Most recently, MacKechnie-Guire *et al* (2020)'s study correlated this suggestion where they observed variations in the muscular dimensions of the T13 region over a period of eight hours. They did acknowledge limitations to the study due to a small sample size of ten horses, implying the variations are due to a change in posture, however these adjustments do hold the potential to influence saddle fit which would necessitate further research in future.

Various effects of the pressures created by saddle fit have been explored since 2007, including that of tree types, widths and panel width (Clayton *et al*, 2014; Greve and Dyson, 2014; Kotschwar *et al*, 2010; MacKechnie-Guire *et al*, 2018a; Meschan *et al*; 2007; Peham *et al*, 2010; Ramseier *et al*, 2013). It has since been assumed that poor saddle fit and saddle roll/yaw would cause compensatory changes to horse kinematics due to the asymmetric forces applied to the thoracic region (Fruethwith *et al*, 2004; MacKechnie-Guire *et al*, 2018a). Saddle kinematics can vary with translational or rotational movement, and any asymmetric forces created through the saddle would have an effect on the contralateral limb loading, as well as thoracolumbosacral kinematics (MacKechnie-Guire *et al*, 2018a). Gunst *et al* published research in 2019 which showed that increase of ipsilateral force created by saddles affects the *m. trapezius pars caudalis* musculature around the scapula, which is responsible for the protraction/retraction of the forelimb, causing

asymmetric distribution associated with the centripetal acceleration and GRF distribution.

2.4 Force

Research by Byström *et al* (2018) suggested that they could not determine that the rider would be more influential to saddle displacement than the horse. However, since the forces created by rider movements are closely linked to equine locomotion, research still needs to consider their influence on saddle displacement. Previous evaluation of pressure distribution has shown that throughout gaits, force changes in relation to the body mass of the rider. At walk the force is seen to be approximately equal to the body mass of the rider, at trot this increases to around twice the body mass, and it can become almost 2.5 times the body mass of the rider during canter (Fruehwirth *et al*, 2004). Investigations also showed that even without a rider, forces on the back created by saddles can reach between 200 – 300N during walk and trot movements, and that this may impede the horses back movement due to the distribution of weight over smaller areas (Fruehwirth *et al*, 2004; Greve *et al*, 2015). However, both Greve *et al* (2015) and MacKechnie-Guire *et al* (2018a) have proposed that mean pressure values of over 11kPa (approximately 11,000N/m²) exceed the threshold where the thoracolumbosacral movement becomes hindered and back pain begins to arise. MacKechnie-Guire *et al* (2018a) found that where saddle roll occurred during locomotion, significantly larger pressures were observed around the T13 region opposite the direction of roll during rising trot, reaching peaks of up to 12.1kPa. Findings also showed that in this area, changes in musculature are evident and it is thought to be associated with saddle slip (MacKechnie-Guire *et al*, 2018b). If comparisons are made to research from Gunst *et al* in 2019, differing ipsilateral forces can cause asymmetrical musculature development, which can be made worse due to traditional habits such as mounting from the left side. However, Gunst *et al* do admit that they would need to carry out further studies to confirm whether

alternating the side of mounting would result in a more even force distribution and even musculature development. MacKechnie-Guire *et al* (2018b) also indicated that the nature of these results demonstrates the value of an optimal musculoskeletal system, which allows the horse to withstand the forces created by the horse-saddle-rider interactions.

2.5 Rider Influence

Knowledge of rider influence on equine biomechanics and symmetry is essential, not only to assist in the detection of low-grade lameness (Persson Sjödin, 2020), but also to note the compensatory movement that rider asymmetry can generate in horses through the horse-saddle-rider interaction (De Cocq *et al*, 2009; Williams & Tabor, 2017; MacKechnie-Guire *et al*, 2018; Clayton & Hobbs, 2017; Byström *et al*, 2019; Symes & Ellis, 2009).

In 2015, Hampson and Randle noted that when either horse or rider in a combination develops an adverse performance contributor, for example an asymmetry, the partner athlete becomes influenced which then compromises the synchronicity between the two. However, Bolton (2018) has since suggested that there is a lack of research investigating the fitness conditioning of horse riders, a factor which would influence rider position and the effectiveness of ridden communication substantially. Although there are varying biomechanical requirements across each discipline, the consistent factor is the need for the rider to remain in a balanced position during riding (Bolton, 2018). Equability and stability in the rider's seat are crucial to provide effective aids for communication between horse and rider (Peham *et al*, 2010), and to achieve coordination of movement with the horse and effective communication, a rider must be capable of achieving a well-balanced, consistent position (Sung *et al*, 2015). But MacKechnie-Guire *et al* (2018a) concluded that asymmetric force distribution through the stirrups can cause asymmetric movements over the thoracolumbarsacral region, as

well as asymmetric loading of the contralateral limbs. This distribution of force was additionally shown to encourage compensatory biomechanics such as hyperextension of the fetlocks and unusual thoracolumbar movement as the horse attempts to recover stability. Williams and Tabor (2017) suggested that this unusual range of thoracolumbar motion is primarily caused by the riding technique and weight of the rider, with the rider producing an adverse effect on lameness during ridden trot ups, with hind limb lameness noticeably escalating. Byström *et al* (2019) discussed that equine asymmetries can be instigated by anatomical asymmetries such as differences in bone dimension, they do at a point discuss the influences from the rider during training but fail to concentrate on this topic further.

2.6 Ridden Behaviour

Equine behaviour has long been used to assess subjective experiences during both ridden work and horse handling. It can be considered over two variations, spontaneous and long term – spontaneous behaviour can be representative of the horse's short term mental state, whereas perpetual behaviour patterns can be used to evaluate the horse's long term mental state (Hall *et al*, 2018).

Horses which display conflict behaviours during ridden activity have been shown by Christensen *et al* (2020) to score lower in rideability categories, with riders finding horses exhibiting these behaviours more challenging to ride. These conflict behaviours can often be seen under-saddle, suggesting a link between the horse-saddle-rider interaction and conflict behaviour, with specific associations between the English style of riding and the frequency of ridden conflict behaviours being reported (Normando *et al*, 2011); corroborating studies suggest that the frequency of these behaviours increase with a rider on board (Piccolo and Kienapfel, 2019). A ridden ethogram was developed by Mullard *et al* (2017) which connected conflict behaviours to pain responses, this included ridden behaviours such as bucking, a reluctance to move forwards and spooking, as well as parts of the horse grimace

scale (Dalla Costa *et al*, 2014) such as teeth and tongue exposing, pinned ears and tense nostrils. Dyson (2017) suggests through her study that saddle slip and the attributed conflict behaviours are primarily caused by hindlimb lameness rather than the traditional thought of asymmetries and ill-fitting saddles. However, there is a growing body of research to show how conflict behaviours can be attributed to a number of different factors. Fenner *et al*'s 2020 study showed us through the use of the E-BARQ (Equine Behaviour Assessment and Research Questionnaire) that stallions and bay horses tended to be bolder than their gelded and chestnut counterparts, and less likely to display conflict behaviours, although this was not demonstrated under saddle. Interestingly, research has also suggested that the design and fit of saddles can influence the occurrence of conflict behaviour, with straighter cut working hunter and dressage saddles proving to be less associated as a risk factor. Other factors such as extended intervals between farrier visits, the use of artificial training aids and less human-horse interaction time had a significant influence on the occurrence of conflict behaviour (Hockenhull and Creighton, 2012). All of this information corroborates the fact that when assessing saddle slip and its associated behaviours, and the fundamental need to consider the multiple factors for causation (MacKechnie-Guire, 2020) and the importance of the horse-saddle-rider interaction (Byström *et al*, 2018).

METHODOLOGY

3.1 Ponies and Riders

A convenience sample of eight ponies (n= 3 geldings, n= 5 mares) were used for this pilot study. Ponies and riders were recruited through the local pony club mounted games team, after being asked to volunteer to participate. The only inclusion criteria provided was that riders were capable of performing the mounted games movements which were included within this study. The horses ranged in age from 7 to 25, and ranged in breed (n= 3 Connemara, n= 2 British Sports Pony, n= 3 Crossbreed). Eight riders (n= 2 male, n= 6 female) rode as experienced mounted games competitors, with combinations training and/or competing at a national level. Information such as pony breed, age, history of lameness, saddle fitting and physiotherapy history was obtained via questionnaire prior to attendance. All riders and ponies were free from injury at the time of the study, informed consent was obtained prior to attendance and riders were informed that they could withdraw from the study at any point should they wish.

3.2 Safeguarding

As participants in this study were minors, prior to commencement an information form was provided, and a consent form was completed and signed by a parent or guardian to ensure voluntary participation and that fully informed consent was received. All participants were made aware through both the information and consent forms that they were able to withdraw from the study at any time without having to give justification. One parent/guardian was required to be in attendance per rider to ensure appropriate supervision. Through following the British Horse Society Accredited Professional Coach safeguarding and video policies, enabled the study to maintain a safe and secure environment for minors to participate. The researcher has awareness of safeguarding and first aid procedures, however a

qualified first aider was on site, alongside a DBS checked coach to ensure wellbeing at all times.

Anonymity was kept consistently, with no identifiable data used with the exception of consent forms. These were collected as hard copies and converted digitally where they are stored on Northumberland College cloud servers, and will be securely destroyed on, but not before, 15.09.2021. Any video footage which was converted into photo stills for this study had no identifiable features of riders, horses or spectators.

3.3 Saddles

The pony's own saddles were used for this study (n= 7 gp, n= 1 jump). They had been checked recently for fit by a Society of Master Saddlers qualified saddler, as determined by the completed questionnaire.

3.4 Study Protocol

Each pony and rider combination went through a 10-minute warm up period which was self-directed by the rider. Data was then collected during a straight-line gallop as a control measurement over three passes. Three repeats were then collected through mounted games movements, the vault, the scoop and then a standing corner vault. If any mistakes were made, or if the horse made any obvious alterations to the stride pattern such as tripping or shying, the trial was repeated. This method of data collection was adopted as it has been shown to be a repeatable, effective form of data collection for this type of study by MacKechnie-Guire *et al* on numerous occasions (2018a; 2018b; 2019; 2020).

3.5 Saddle Kinematics

Kinematic data was recorded using a Casio Exilim 9.1mp video camera shooting at 1000fps, alongside five half sphere skin markers (30mm) (Centaur Biomechanics, 25

Oaktree Close, Warwick, CV35 9BB), which were placed on each horse using double sided tape. Marker locations were at the midpoint of the cantle, and at placed approximately at the L6, S2, S4, and C2 vertebrae (Plate 2). These marker locations were identified as points where differentiations from the midline of the horse and where the saddle is intended to be situated and are evenly spaced enough to be visible in image format. Each set of markers was disinfected between uses due to national Coronavirus guidelines.

One camera was placed 1 metre from the track where the experiment was to take place, which would capture the rear profile of the horse. Video data was collected and downloaded to a laptop (Sony Vaio, PCG-91111M) and then processed through Quintic Biomechanics two-dimensional motion capture software. Automatic marker tracking was used to investigate the occurrence of saddle slip, and the degree of slip severity to either left or right.

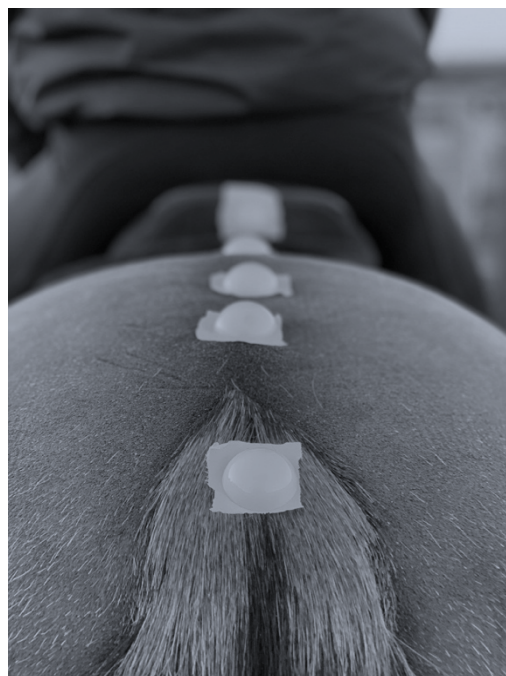


Plate 2: Image showing the placement of the half sphere markers along the thoracic midline on Horse B

3.6 Data Collection

From the kinematic analysis of two-dimensional video footage, data was collected from three repeats of three mounted games movements, (1) scoop (2) vault (3) standing corner vault, as well as three repeats of the control movement, totalling 12 passes per ridden combination. Outcome parameters for each combination through each movement were (1) saddle slip, and (2) degree of saddle slip left or right. Through the questionnaire completed prior to attendance, data collected included (1) breed and age of the pony, (2) the status of saddle fitting, (3) history of lameness, (4) attendance by an ACPAT physiotherapist and (5) rider's perception of saddle slip (Appendix I). This information will be collated and used to form any connections between these subjects and the degree or presence of saddle slip.

3.7 Statistical Analysis

Statistical analysis was performed in Minitab (Minitab, version 19.2020.1 (64-bit)). For all outcome parameters, the significance level was set as $p \leq 0.05$. As the data met parametric assumptions, a One-Way ANOVA statistical test was performed followed by two paired t-tests to test the hypotheses (H_0 , H_1). These tests provided us with values which determined if there was significance in the results of the data collection.

CORONAVIRUS

4.1 *Coronavirus (COVID-19/SARS-2)*

Due to the ongoing Coronavirus pandemic, adaptations have been made as to the way this data will be collected so it can be carried out safely and effectively (Ziegler and Mason, 2020). It was determined which information was important to collect, and how much of it needed to be collected. As of January 4th, 2021, the United Kingdom entered a National Lockdown (Gov.uk, 2021), with both British Equestrian and the British Horse Society placing restrictions on horse owners and professionals. These restrictions included that one-to-one coaching at a coach's home facility is acceptable providing COVID practices are observed, and where social distancing can be maintained at all times, venue hire closed with transport of horses being deemed as non-essential unless for welfare reasons (British Equestrian, 2021). These regulations which were put in place meant that the arena hire at Kirkley Hall was unable to be utilised, and participants were unable to travel to the venue. However, having two liverys on home facilities who are national Mounted Games competitors meant research could still be completed involving them and their ponies as a pilot study. One of the rider's guardians is a practising Police Officer, which provided suitable adult supervision and qualified first aider.

Although the study does not have the data which would have been collected had the original design gone ahead, it did successfully collect data which confirms that the data collection was feasible and provides the results which are needed to try and prove or disprove the hypothesis (Morin, 2013). A full review of the risk assessment was carried out under the new guidelines and approved by both the University of Cumbria and the Dissertation Supervisor. This included precautions such as wearing of masks by the researcher and single spectator, and that the

parent/guardian spectating is to keep a 2m distance from the researcher and rider at all times.

4.2 Changes to Convenience Sample

Due to the study protocol changes caused by Coronavirus, the convenience sample changed. The sample was reduced to two riders (n= 2 female), and three ponies (n=1 gelding, n=2 mare). The ponies ranged in age from 12 to 21, and in breed (n=1 Connemara, n=2 Crossbreed). Both riders and horses ride as experienced mounted games competitors, with combinations training and competing at a national level. The pony's own saddles were still used for this study (n=3 gp). They had been checked recently for fit by a Society of Master Saddlers qualified saddler, as determined by the completed questionnaire. Because all riders who are involved in the study are female, this does cause some bias, however, the equestrian industry is predominantly female based with fewer male competitors (Dashper, 2012). Cronbach's Alpha measure of internal consistency would suggest that for the data to be reliable, it should be representative of the sample's population (Hertzog, 2008). Though this sample is no longer wholly representative of the population, it does hold a high resemblance to the majority. It provided us with data and results that will be successfully utilised going forward in further research.

RESULTS

5.1 Control Movement Saddle Slip

Mean degree of saddle slip during the control movements was 7.40 °, with values ranging between 0.31° and 10.86°.

	<i>Movement (in ° degrees)</i>								
	Control	SD	Mean	Vault	SD	Mean	Scoop	SD	Mean
Horse A		±0.991	9.897		±1.097	8.323		±3.14	24.530
Pass 1	9.950			9.590			28.120		
Pass 2	10.860			7.670			23.140		
Pass 3	8.880			7.710			22.320		
Horse B		±3.99	4.900		±1.96	14.700		±2.1	23.760
Pass 1	0.310			13.920			24.000		
Pass 2	6.830			13.240			21.550		
Pass 3	7.560			16.930			25.720		
Horse C		±1.243	6.067		±11.39	25.230		±2.11	15.260
Pass 1	6.230			12.930			13.610		
Pass 2	4.750			27.360			17.640		
Pass 3	7.220			35.410			14.530		

Table 1: Table showing results of each movement pass by horse, including the standard deviation and mean values.

5.2 Saddle Slip During Vault Movement

During the vault movements, the mean degree of saddle slip was 11.51°. A significant difference was seen ($p=0.034$), with a SD $\pm 10.76^\circ$. The mean degree of slip to the right increased by 55.54%. Degrees of slip to the right ranged between 7.67° and 16.93°. The increase in the degree of slip does not appear to be consistent between horses. Horse A had a decrease of 15.87% in slip compared to increases in Horse B with 52.07% and Horse C with 316.33%. There was a statistically significant difference between movements as determined by one-way ANOVA ($F_{2,24} = 11.44$, $p < 0.05$).

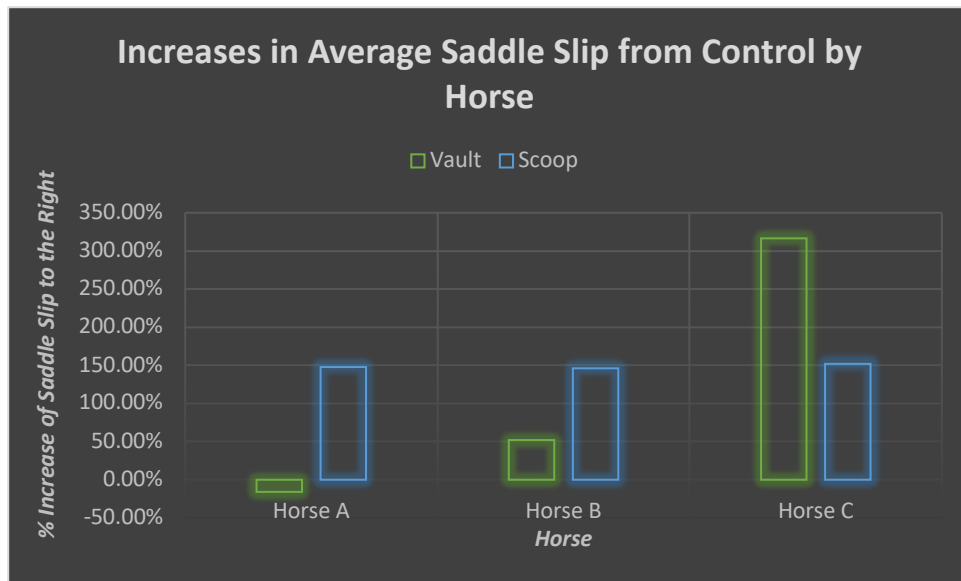


Table 2: Graph showing mean values of saddle slip by horse.

5.3 Saddle Slip During Scoop Movement

During the scoop movements, the mean degree of saddle slip to the right was 24.14° . An extremely significant difference was seen ($p < 0.001$), with a $SD \pm 5.26^{\circ}$. The mean degree of slip to the right increased by 226.21%. Degrees of slip to the right ranged between 21.55° and 28.12° . The increase in the degree of slip appears to be consistent between horses, with increases of 147.92% in Horse A, 145.86% in Horse B, and 151.65% in Horse C. There was a statistically significant difference between movements as determined by one-way ANOVA ($F_{2,24} = 11.44$, $p < 0.05$).

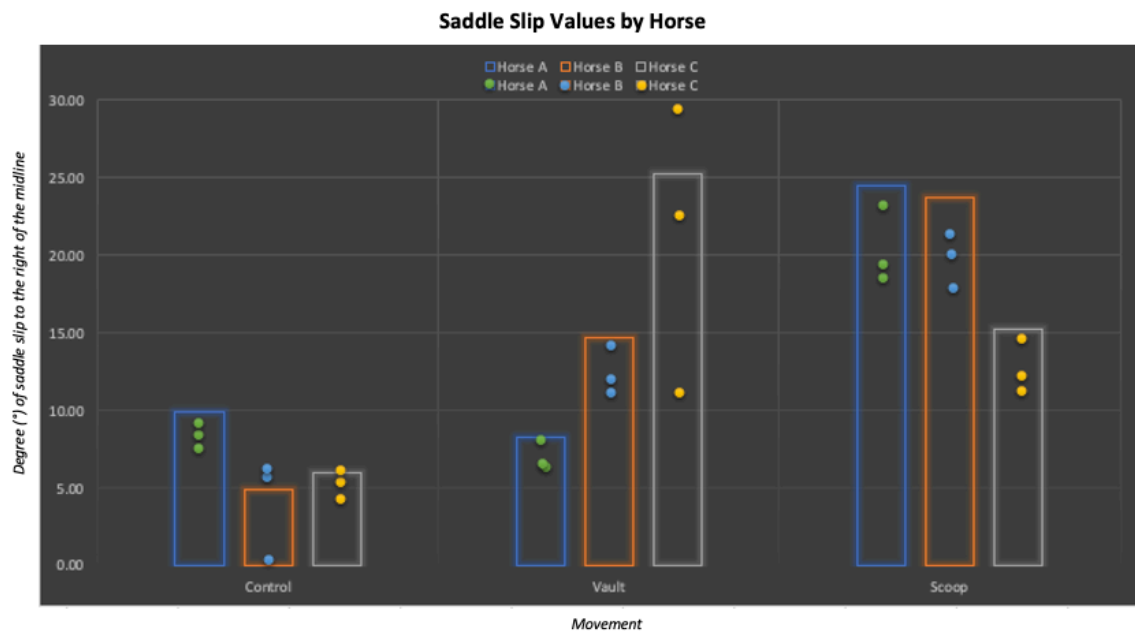


Table 3: Graph demonstrating the mean degree of saddle slip for each horse by movement. The smaller dots represent each pass of the movement.

5.4 Saddle Slip During Standing Corner Vault Movement

This movement did not take place during the gathering of data. This was because during the standing corner vault, the participants knocked off 3 of the half sphere skin markers with their leg, meaning that the study would be unable to accurately determine the degree of saddle slip in this movement.

Horse	Breed	Age	Prev Lameness	Details	Physio	Last Seen	Saddle Fit	SMS	Date	Saddle Slip?	How much?
A	Connemara	12	No	N/a	Yes	Sep-20	Yes	Yes	Dec-20	Yes	Med
B	Welsh X	21	No	N/a	No		Yes	Yes	Jun-20	Yes	Med
C	Connemara X	14	No	N/a	Yes	Sep-20	Yes	Yes	Sep-20	Yes	Small

Table 4: Table showing questionnaire results by horse

5.5 Questionnaire Results

All three riders completed the questionnaire (Table 2). None of the horses had any previous history of lameness. Of the horses in the study, 66.66% had seen a registered physio in the last 6 months (n=2). All three saddles had been fitted within the last 6 months by a registered Society of Master Saddlers Saddler. All of

the riders (100%) of riders were aware that their saddle slipped, 66.66% of these riders believed their saddle slipped a medium amount (n=2), and 33.33% of the riders believed their saddle slipped a small amount (n=1)

DISCUSSION

This study was designed to allow us to establish the occurrence of saddle slip in Mounted Games ponies throughout a variety of Mounted Games movements. The results have shown that saddle slip is significant in Mounted Games ponies and therefore proved the H_1 hypothesis.



Plate 3: Image showing Horse A presenting the highest degree of saddle slip during the Scoop movement at the stance phase of the stride cycle. The red lines demonstrate the 28.12° of saddle slip to the right.

Interesting visual evidence was discovered that suggests that the highest degree of saddle slip occurs during the stance phase of the inside leg on the side of lean (right). As the rider leans, the horse's trunk follows in the lean, similar to that in centripetal acceleration, and there is no significant slip, however as the inside hindleg lands the saddle slip appears (Plate 3). Similarly, research by Byström *et al* (2018) found that during the stance phase of the stride cycle, the vertical impulse forces were reduced, but the propulsive impulse force horizontally could result in the rider's hip being pushed forward, in turn decreasing the roll rotation of the pelvis, and increasing the yaw rotation which would amplify the lateral rotation of the saddle, and therefore the saddle slip. As an industry, we have to consider the

effect that the rider has on the saddle slip if comparisons are being made between this study and others. There is a high correlation between rider asymmetry and saddle slip, as has been shown in a number of previous studies (De Cocq *et al*, 2009; Williams & Tabor, 2017; MacKechnie-Guire *et al*, 2018; Clayton & Hobbs, 2017; Byström *et al*, 2019; Symes & Ellis, 2009). It must be noted that saddle slip is always to the right in this research, this is connected to rider lean and associated with the configuration of Mounted Games movements. This is the direction of turns, movements and how the pick-up of objects is set up in every training and competition Mounted Games environment, for the rider to lean to the right. Münz (2014) showed that handedness made a difference to rider asymmetry and influenced horse laterality, which differs from these findings. Throughout Mounted Games training, all riders are taught to lean to the right, regardless of handedness, because of the configuration of competition. Rarely some riders do take their handedness into account and lean left, however they have to turn inversely which takes additional time, so this is often avoided to reduce the impact to performance.

The most important finding was that the saddle slip is significant ($p < 0.05$) in both the vault and the scoop movements and this is important in two respects as can be seen in Table 3. Firstly, the degree of slip is not consistent between ponies in the vault movement, it varied significantly between all three combinations in the sample (A= 15.87%, B= 52.07%, C = 316.33%). Some ponies had reductions in the % of slip increase from the midline, compared to some significant increases in slip from other ponies. Interference from the rider cannot be ruled out in this case, however the same rider rode two of the ponies involved, which would suggest that causation from the rider may not be a conclusive explanation for these results and would warrant further investigation. In comparison, the degree of slip in the scoop movement is consistent between all three ponies (A= 147.92%, B= 145.86%, C= 151.65%). All ponies had a significant increase in the % increase of saddle slip from

the midline which as discussed earlier could be attributed to the rider's asymmetry during the movement, and the relative movement of the pony's biomechanics throughout the stride cycle. The levels of increase between the two movements cannot be directly compared because of the differing locomotory aspects between pony and rider, however the differences in consistency can allow us to assume that the incidence of saddle slip does occur but has levels of variation between all movements. Although there cannot be a certain definition of the negative impacts of the slip discovered in this study, it can be assumed from Gunst *et al's* (2017) research that the rider's intentional movement down through the right hip would significantly increase saddle pressures experienced by the pony during the movement, however their study suggested higher loading is seen to the left. Due to the rider's movements in Mounted Games, it would be presumed that the loading would be to the right, however this would need to be determined through the correct use of experimental design in future studies. Pliance pressure mats have been used in a number of existing studies (MacKechnie-Guire *et al*, 2018a; 2019) to measure pressure values across the back which can be created by both saddles alone and with the inclusion of the rider, this could be a consideration for the study in future. MacKechnie-Guire *et al's* (2020) study also suggests, through the use of induced rider asymmetry, that the ponies in this study may potentially develop increased biomechanical compensations and experience reductions in performance due to the increased pressures created by both saddle slip and rider asymmetry, with some of these potentially exceeding the painful 11kPa limit.

In relation to the questionnaire provided to the sample, there was no noticeable correlations between saddle slip, and when the saddle was fitted. Interestingly however, rider C had noted they believed their saddle slipped only a small amount, but during the study they had the highest increases in slip % increase (Vault= 316.33%, Scoop= 151.65%). This implies that rider perceptions may underestimate the severity of saddle slip, as was seen in Greve & Dyson's (2014a)

study into saddle fit and management. This can sometimes be attributed to a lack of education, as it was in the 2014(a) study, but could also be recognised as what is known in psychology as the ‘ostrich problem’. Rather than assuming a lack of knowledge, incidences such as this can occasionally be associated with situations where riders do have comprehension of the issues occurring, but fail to consider the implications of not using this knowledge to resolve complications. It has been suggested by Webb *et al* (2013) that the manifestation of the ‘ostrich problem’ can be down to a number of factors, including the use of it as a defence mechanism, a case of unintentional biases or even a conscious and intentional approach to potential threats. This, however, would be difficult to determine because of the probability of participant bias – but would prove to be an interesting subject to probe in future.

All three ponies were seen regularly by qualified physiotherapists but had no history of previous lameness. The potential of any undesirable musculoskeletal impact to the pony caused by compensatory locomotion being relieved by regular physiotherapy must be considered. It is not to say that there is no negative impact caused to the pony through the saddle slip, but the current management of the pony could be beneficial to reducing pain or poor performance (Greve & Dyson, 2014a). Desired outcomes for equine physiotherapy are usually, but not limited to, achievement of peak performance (Tabor, 2020); but it must also be noted that the conformation of ponies can have a contributory factor in their biomechanics (Druml *et al*, 2016). Horse owners’ priorities are usually based around maintaining a pain free horse for optimal musculoskeletal health, performance reasons and welfare (Egan *et al*, 2019), which would link to the benefits experienced by the Mounted Games ponies used in the sample. There are strong associations suggested in current research between saddle fit, epaxial muscle tension and pain (Dyson *et al*, 2019), which begs the question if the regular checking and correct fitting of saddles is improving potential problems in these areas. Issues such as

muscular atrophy and pain in the thoracolumbar area are always a risk when horses are ridden in ill-fitting saddles (von Peinen *et al*, 2010; Greve *et al*, 2015), with conflict behaviours becoming more apparent when this is the case. Dyson *et al* (2021) discovered that 34% of horses display conflict behaviours during and after saddling, suggesting relationships between saddling and either pain or the expectation of pain. Of the 34%, 78.2% of the saddles were seen to have potential negative impacts to the horse as they either had not been fitted or had not been checked for a period longer than 6 months. Despite research concentrating on the effects of various girth designs on the pressure points in the ventral thoracic region (Murray *et al*, 2013), there is no consideration as to types and fit of girths potentially improving saddle slip, nor is any concentrated on types and shapes of saddle pads and numnahs. Being able to appropriately improve the horse-rider connection, the correct saddle fit, and saddle fitting procedures is essential to create the enhanced athletic performance of both the horse and rider combination (MacKechnie-Guire *et al*, 2018). Because the ponies used in the sample of this study showed no conflict behaviours during ridden work, it can be safely assumed that there are no concerns with the management of saddle fit, or the pain levels experienced by ponies at the time of the study.

Regardless of the significance, the results should be interpreted with caution and the limitations of the study should be considered. The major limitation was the sample size. Unfortunately, due to Coronavirus, the UK National Lockdown and guidance set out by UK Equine Governing Bodies (Gov.uk, 2021; British Equestrian, 2021), the availability of participants and travel to data collection locations was restricted. Smaller sample sizes are normally viewed as being threatening to the validity of results and perceived as being insufficient, however it has been considered that the most important factor is for data to be adequate and representative of the general population (Vasileiou *et al*, 2018). Although the sample used consisted wholly of female participants, the equestrian industry has

generally been shown to be female dominated (Dashper, 2012), and this sample is something which can aim to be rectified and investigated in expansions of this study. It is common for small sample sizes to lead to non-normalised distribution of results (Civelek, 2018) however this was not experienced with any data collected in this study. Vasileiou *et al* (2018) argued that in quantitative research, there is no definitive answer to how large or how small a successful sample size needs to be. The dependant factors on the research are between the study's epidemiology, the practical methodology and the successful interpretation of results. Being a pilot study with a small sample size, it is important to remember that the potential of the results creating false positives or false negatives is high. In contrast, this type of study is an important part of the experimental research, exploring the practicability of the methodology with the intent of progressing on to larger scale studies (Leon *et al*, 2011). This study has shown that the methodology is successful in determining results, and a larger sample size in future will assist in confirming what looks to be a proven H_1 hypothesis.



Plate 4: Image showing high amount of saddle slip through the standing corner vault movement during pilot testing of the experimental design.

Through the initial pilot testing stages of this study, results from the standing corner vault movement suggested a significant amount of saddle slip (Plate 4). However, when there were attempts to measure this in the final stages of data collection it was not feasible. Unfortunately, when performing the movement and the rider was swinging the leg over the saddle, the rider's feet either moved or knocked off the half sphere skin markers, which meant the degrees of slip created could not be accurately measured. In future circular disc markers in place of the half sphere marker could be utilised, as they lie closer to the pony's back, making them more difficult to knock off or out of place. By acknowledging this issue, gaining an awareness of what can go wrong will assist in making sure future studies can continue to be successful, effective and provide crucial data (Tight, 2015).

As has been discussed previously, there is no existing research into the subject of saddle slip in Mounted Games ponies, which provided no foundation for this research, and no existing methodology or results to compare. Nonetheless, the utilisation of current studies explaining saddle slip in elite dressage and jumping horses has been imperative to helping inform experimental design and identifying important gaps in knowledge and areas for further development (Byström *et al*, 2010; MacKechnie-Guire *et al*, 2018a; 2020). There is no current research determining the degrees of saddle slip solely across dressage and jumping movements other than those incorporating rider asymmetries or lameness in horses (MacKechnie-Guire *et al*, 2020; Dyson *et al*, 2015). From this unfortunately no comparisons can be made as to whether saddle slip is larger in Mounted Games ponies and determine the reasons why this is, however, it would make interesting research in future to compare saddle slip across varying disciplines and their respective movements. Additional comparisons could be made across all disciplines including that of cross country, barrel racing and western riding. By being able to recognise where research needs to be maximised in order to

address questions and improve horse welfare, by identifying key themes which are needed to concentrate further studies on and help to move the industry forward (Robinson *et al*, 2011).

No recommendations can be made from this study, this is due to the research being based on the investigation into the occurrence of saddle slip, rather than any contributing factors. Considerable amounts of room for further research into this subject seem accessible, including repetition of the study with larger sample sizes, including excluded movements and moving into other disciplines such as horse ball, which has very similar rider movements at speed. Utilising existing research such as the Horse Grimace Scale and Ridden Ethogram (Dalla Costa *et al*, 2014; Mullard *et al*, 2017), and perhaps linking them with Fenner *et al*'s (2020) E-BARQ can assist us in determining the ridden behaviours of Mounted Games ponies. This could be done either visually through historical motion capture data or have comparisons of live visuals from a number of industry professionals. By doing this, studies can look to identify any conflict behaviours as they occur and likely the pain measurements of the ponies during Mounted Games competition to further consider welfare improvements in the sport. Similar to prior research studies (Byström *et al*, 2010; MacKechnie-Guire *et al*, 2018a; 2020), going forward there are an abundance of options to enable further studies to explore the broader subject of saddle slip, assess the negative impact and determine the exact biomechanical compensations created by ponies throughout Mounted Games movements and the exact causations of their saddle slip. Only then can the industry look to encourage and endorse changes to provide marginal gains to competition performance.

CONCLUSION

This project was undertaken to determine the occurrence of saddle slip in Mounted Games ponies. The most obvious finding which has emerged is the demonstration of the H_1 hypothesis, where saddle slip does occur across various Mounted Games movements. Investigations discovered that the percentage of increase in saddle slip varied across movements, with the vault being inconsistent between ponies used in the sample, and the slip in the scoop being consistent, both with significant results. If the results with the knowledge gained from previous saddle slip studies are taken into consideration, it can be assumed that there will be biomechanical compensations from the ponies, and the potential of other negative impacts such as muscular atrophy caused by increased pressure (von Peinen *et al*, 2010; Greve *et al*, 2015). This raises important questions into the welfare and social license of Mounted Games worldwide, but also about how horse owners, trainers and governing bodies can improve horsemanship going forwards to balance these undesirable effects.

With clear limitations created due to the Coronavirus pandemic, it would be a viable option to rerun this study with a larger sample size to assess if the methodology would produce the same results, or if there are any comparisons to be made and additional questions to be answered. Notwithstanding this, the study did provide a comprehensive and successful methodology, providing significant parametric data with areas of consistency that can be utilised efficiently in research going forward. There is an obvious natural progression for the study to consider further aspects of saddle slip in Mounted Games, including that of the biomechanics and use of pressure mats and inertial sensors to collect kinematic and kinetic data.

This study not only adds to the existing body of research into saddle slip but lays foundations for potential research in future. Existing research on saddle slip, its causes and positive change has already begun to encourage marginal gains in competition performance and improve welfare for ridden equines (Byström *et al*, 2010; MacKechnie-Guire *et al*, 2018a; 2020). These findings could have a number of important implications for future equine practice, both positively and negatively in competition and training, not only in Mounted Games but also in similar disciplines such as Horse Ball. Once there is a clearer understanding of the welfare and performance complications created through the Mounted Games riding styles and movements, horse owners and trainers in industry, as well as researchers, will begin to develop a cognitive awareness of the long-term effects on ponies and how we can further advance this research in future.

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APPENDIX I



Saddle Up: An Investigation into the Prevalence of Saddle Slip in
Mounted Games Ponies
Participant Questionnaire

Please circle or delete answers where appropriate.

Pony Breed

Pony Age

Has the pony had any previous lameness whilst training/competing in
Mounted Games? YES NO

If yes, please provide condition/details

.....
.....
.....
.....

Does your pony regularly see a registered equine physiotherapist? YES
NO

If so, when was the last time they were treated?

Has your saddle been professionally fitted? YES NO

If so, when was the last time this was checked?

Was the saddle checked by a Society of Master Saddlers approved saddle
fitter? YES NO

Do you believe your saddle slips? YES NO

If yes, how much?

A SMALL AMOUNT A MEDIUM AMOUNT A LARGE
AMOUNT