A Preliminary Study Investigating Functional Movement Screen Test Scores in Female Collegiate Age Horse-riders

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Abstract

The functional movement screen (FMS) is an easily administered and non-invasive tool to identify areas of weakness and asymmetry during specific exercises. FMS is a common method of athlete screening in many sports and is used to ascertain injury risk, but has to be used within an equestrian population. The aim of this study was establish FMS scores for female collegiate age (18-26yrs) riders, to inform a normative data set of FMS scores in horse riders in the future.

Thirteen female collegiate horse riders (mean ± s.d.; age 21.5 ±1.4 years, height 167.2 ±5.76 cm, mass 60.69 ±5.3 kg) and 13 female collegiate non-riders (mean ± s.d.; age 22.5 ±2.1 years, height 166.5 ±5.7 cm, mass 61.5 ±4.9kg) were assessed based on their performance on a 7-point FMS (deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability and rotary stability). The mean composite FMS scores (± s.d.) for the rider group was 14.15 ± 1.9 and for the non-riders was 13.15 ± 1.77. There was no statistical significant difference in median FMS composite scores between the rider and non-rider groups (Mann-Whitney U test, z= -1.249, p=0.223). However, 46% of riders and 69% of non-riders scored ≤14, indicating that a non-rider is 1.5 times (O.R.) more likely to be at increased risk of injury compared to riders.

Collegiate female riders scored higher than the non-rider population, but lower than seen in other sports suggesting some riders may be at risk of injury. Riders' FMS scores demonstrated asymmetric movement patterns potentially limiting left lateral movement. Asymmetry has a potential impact on equestrian performance, limiting riders' ability to apply the correct cues to the horse. The findings of such screening could inform the development of axillary training programmes to correct asymmetry pattern and target injury prevention.

Keywords: Horse riding, equestrian, functional movement screen, injury, asymmetry

Introduction

Horse riding involves establishing a relationship between horse and rider, and is described as a hazardous sport (Ball *et al., 2007)*. The relationship requires clear communication that is reliant on the rider maintaining balance and posture in order to be able to administer predictable cues (aids). The rider aims to maintain a straight line through the ear-shoulder-hip-heel, with the pelvis in the neutral position and a controlled upright trunk position adapting to the movement of the horse (Guire *et al.*, 2017; Hobbs *et al.*, 2014; Nevison *et al.*, 2013; Douglas *et al.*, 2012; Lovett *et al.*, 2005). If the rider is unable to maintain this desirable position then they are less likely to be able to control their body movements, administer repeatable predictable cues to the horse and are increased risk of losing their balance or causing undesirable behaviours in the horse.

Research concludes that riders are at risk of acute injuries whilst handling horses, as a result of falling off the horse when riding (Whitlock, 1999; Sorli, 2000; Moss *et al.*, 2002) and as a result of overuse injuries (Kraft *et al.*, 2007; Lewis, 2017; Lewis *et al.*, 2018). Overuse injuries can be caused by the repetitive movement patterns experienced during riding and the repetitive nature of tasks required to care for horses e.g. mucking out. Horse-riders have been reported as frequently having an asymmetric posture linked to years spent riding horses and influenced by their competitive level (Symes and Ellis, 2009; Hobbs *et al*., 2014). As such they are at risk of spinal instability, contributing to overuse injury and inevitably leading to back pain (Al-Eisa *et al*., 2006; Symes and Ellis, 2009; Lewis, 2017; Lewis *et al*., 2018).

Equestrian sports, unlike many others, offer the potential for an extended career, with riders often starting to ride as young as three years old and still competing at the Olympics at sixty years old (Dumbell *et al.*, 2018). As such, equestrian sports are categorised according to Long Term Athlete Development (LTAD) models to be an 'early start-late specialisation' sport (Balyi *et al.*, 2013). With the potential of an extended career, the equestrian specific Long Term Participant Development (LTPD) model focusses on the components of physical literacy that will maintain and develop elite performance for an extended period of time (De Haan, 2017; BEF, 2018). This extended career increases the risk of overuse injuries and that pain, asymmetry and injury may affect not just the individual whilst riding but also off the horse during everyday life. LTPD is a model that defines the most appropriate environment and activities for a given athlete as they develop, and applies to recreational and competitive riders alike (BEF, 2018). The LTPD model considers each individual athlete throughout their equestrian career and offers an insight into optimal training and recovery programmes to ensure athletes reach their potential. The British Equestrian Federation considers off horse training for riders to be important, with a clear focus on functional symmetry, stability, mobility and balance training (BEF, 2018). The LTPD model suggests that riders' body alignment and functional stability patterns should be regularly tested, yet a standardised, quantitative and valid measure has yet to be investigated within this population.

The Functional Movement Screen (FMS) is a simple measure to identify asymmetry in a person's basic functional movements. It was originally designed to assess muscle flexibility, strength, imbalances and general movement proficiency using a range of performance tests. It also identifies deficits related to proprioception, mobilisation, stabilisation and pain within the prescribed movement patterns (Cook *et al*., 2006). It is a screening process growing in popularity due to it being a rapid, non-invasive measure to identify potential injury risk (Cook *et al*., 2006). The screen consists of seven different functional movements that assess trunk and core strength and stability, neuromuscular coordination, asymmetry in movement, flexibility, acceleration, deceleration, and dynamic flexibility (Peate *et al*., 2007). The FMS measures the quality of the movement based on specific criteria that allow the evaluator to use quantitative values for the movement on a scale of 0–3. The FMS focusses on the efficiency of movement patterns rather than the quantity of repetitions performed. It has been used as a tool for injury prevention (Kiesel *et al*., 2007; Kiesel *et al*., 2011) and has proven to be a valid indicator of injury risk among elite athletes. Research also indicates that the FMS demonstrates moderate-to-excellent inter- and intra-rater agreement for most of the assessment protocols (Leeder *et al.*, 2013; Shiltz *et al.*, 2013).

Despite the growing interest in the use of functional movement screen (or similar screening protocols) within athletic development programmes, no published reports have explored the use of FMS testing in horse-riders. This would potentially be a useful non-invasive and quantitative measure that could be implemented with the physical preparation of a horse rider as indicated necessary in the LTPD documentation. Therefore, the assessment of movement proficiency should be viewed as an essential factor in a rider's developmental physical preparation programmes. Consequently, the aim of this research was to establish FMS scores for regular female collegiate age horse riders, to inform a normative data set of FMS scores in horse riders in the future.

Methods

Participants

Two groups of female participants took part in this study, who were all collegiate age (between 18 and 26 years old). Thirteen female riders who rode at least three times per week (mean ± SD age 21.5 ± 1.4 years; height 167.2 ± 5.8 cm; mass 60.69 ± 5.3 kg) formed the rider group. Thirteen non-active collegiate non-riders (who completed no purposeful training regimen) (mean ± SD age 22.5 ± 2.1years; height 166.6 ± 5.7 cm; mass 61.6 ± 4.9 kg) formed the non-rider group. Participants were a convenience sample of volunteers that met the inclusion criteria. Inclusion criteria required all participants to be at least eighteen years of age, injury free and not experiencing pain at the start of the protocol. The experimental protocols received Institutional Ethics Committee Approval and informed written consent was obtained from all participants.

Testing Procedures

Riders were familiarized with the test protocols using verbal guidelines and visual demonstrations, which allowed for some cueing and ensured riders were aware of the requirements of each movement task. All participants were advised to report for testing rested (i.e. having performed no strenuous exercise in the preceding 24 hours), euhydrated and at least 3 hours following the consumption of a light carbohydrate based meal (Winter *et al.,* 2007). Participants were required to perform the procedures with no prior warm up or physical activity, to increase the validity of the results.

Functional Movement Screen

Participants were screened using the seven point functional movement screening protocol described by Cook *et al.* (2006) and Kiesel *et al.* (2007). Each participant performed 7 different functional movements:

'1) the deep squat which assesses bilateral, symmetrical, and functional mobility of the hips, knees and ankles, 2) the hurdle step which examines the body's stride mechanics during the asymmetrical pattern of a stepping motion, 3) the in-line lunge which assesses hip and trunk mobility and stability, quadriceps flexibility, and ankle and knee stability, 4) shoulder mobility which assesses bilateral shoulder range of motion, scapular mobility, and thoracic spine extension 5) the active straight leg raise which determines active hamstring and gastroc-soleus flexibility while maintaining a stable pelvis, 6) the trunk stability push-up which examines trunk stability while a symmetrical upper-extremity motion is performed, and 7) the rotary stability test which assesses multi-plane trunk stability while the upper and lower extremities are in combined motion' (Kiesel *et al.* 2007, p.148).

After each movement, a score was given to the movement based on specific FMS criteria by a qualified sports therapist. A score of 3 indicated that the movement was completed both pain-free and without compensation. A score of 2 indicated that the movement was completed pain-free but with some level of compensation or aid, and a score of 1 indicated that the participant could not perform the movement. A score of 0 was assigned to a movement that induced self-reported pain. When a FMS is performed, 5 of the 7 tests (hurdle step, shoulder mobility, active straight leg raise, in-line lunge, and rotary stability) tests are scored independently on the right and left sides of the body, whilst the other two the deep squat and the trunk stability push up test are symmetrical tests. Participants were given three trials of each movement pattern, with each trial being scored by the same researcher real time on a 0-3 point scale. Based upon the relationship between neuromuscular asymmetry and injury risk, the FMS scoring system highlights asymmetry and takes the lowest score of the three as the overall score for that movement (Beckham, 2010). After the 7 different movements were evaluated, a cumulative score out of 21 was recorded, as per the method described by Cooke *et al.* (2006) where 0 is very low and 21 is the highest score possible .

Statistical Analyses

Descriptive statistics were used to report scores and percentages within data. Odds ratios were utilized to assess risk of injury based on mean composite FMS scores. Due to the ordinal FMS scoring system a non-parametric Mann Whitney- U statistic was used to test for difference between rider and non-rider groups. An alpha value was set at $p<0.05$ (confidence interval 95%) throughout unless otherwise stated. Data were analysed using SPSS for Windows version 24.

Results

The mean composite FMS scores (± SD) for the rider group was 14.2 ± 1.9; and for the non-rider group was 13.2 ± 1.77 (Figure 1). There was no statistical significant difference for FMS composite scores between the rider (14.2±1.9) and non-rider (13±1.8) groups (Mann-Whitney U test, z= -1.249, p=0.223). However, 46 % of riders and 69 % of non-riders scored ≤14, indicating a risk of injury (Table 1) with an odds ratio of 0.67:1 in riders: non-riders. A non-rider is a 1.5 times more likely to be at risk of an injury based on their composite FMS score.

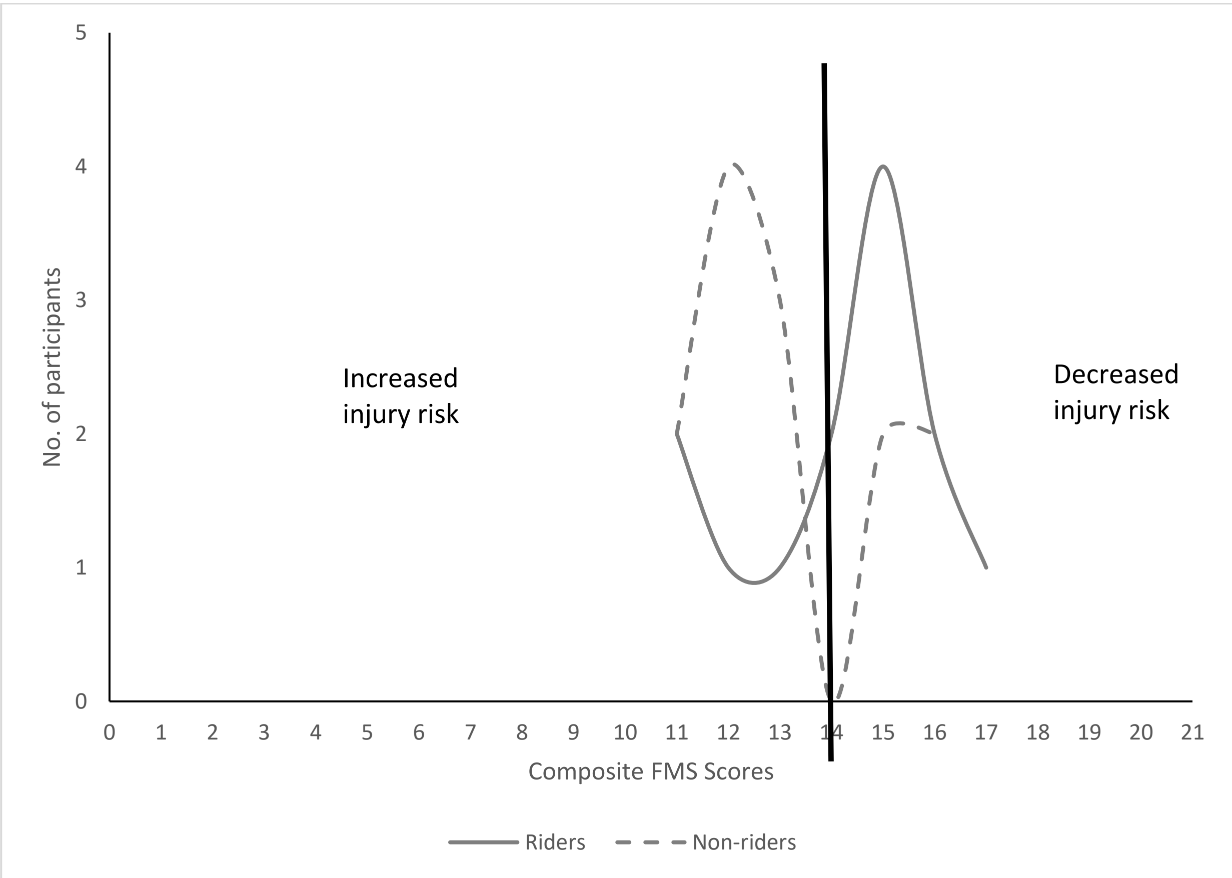

Figure 1. Distribution of composite FMS scores demonstrating decrease in injury risk seen in the group of female collegiate horse riders.

Table 1. A comparison of Functional Movement Screening composite scores for a group of female collegiate horse riders compared to a group of female collegiate non-horse riders

	Number of Participants (n)	Mean composite score	Standard deviation (±SD)	Range of scores	Number of scores ≤ 14	Number of scores >14	Odds ratio
Rider	13	14.15	1.9	11-17	6 (46%)	7 (54%)	Rider: Non-rider 0.67 : 1
Non-rider	13	13.15	1.8	11-16	9 (69%)	4 (31%)	

FMS for individual exercises (Figure 2) showed no significant difference between the two groups but did show high variability especially in riders' trunk stability. No significant difference was seen in absolute asymmetry between riders and non-riders (Mann-Whitney U test, n=23, all p>0.05).

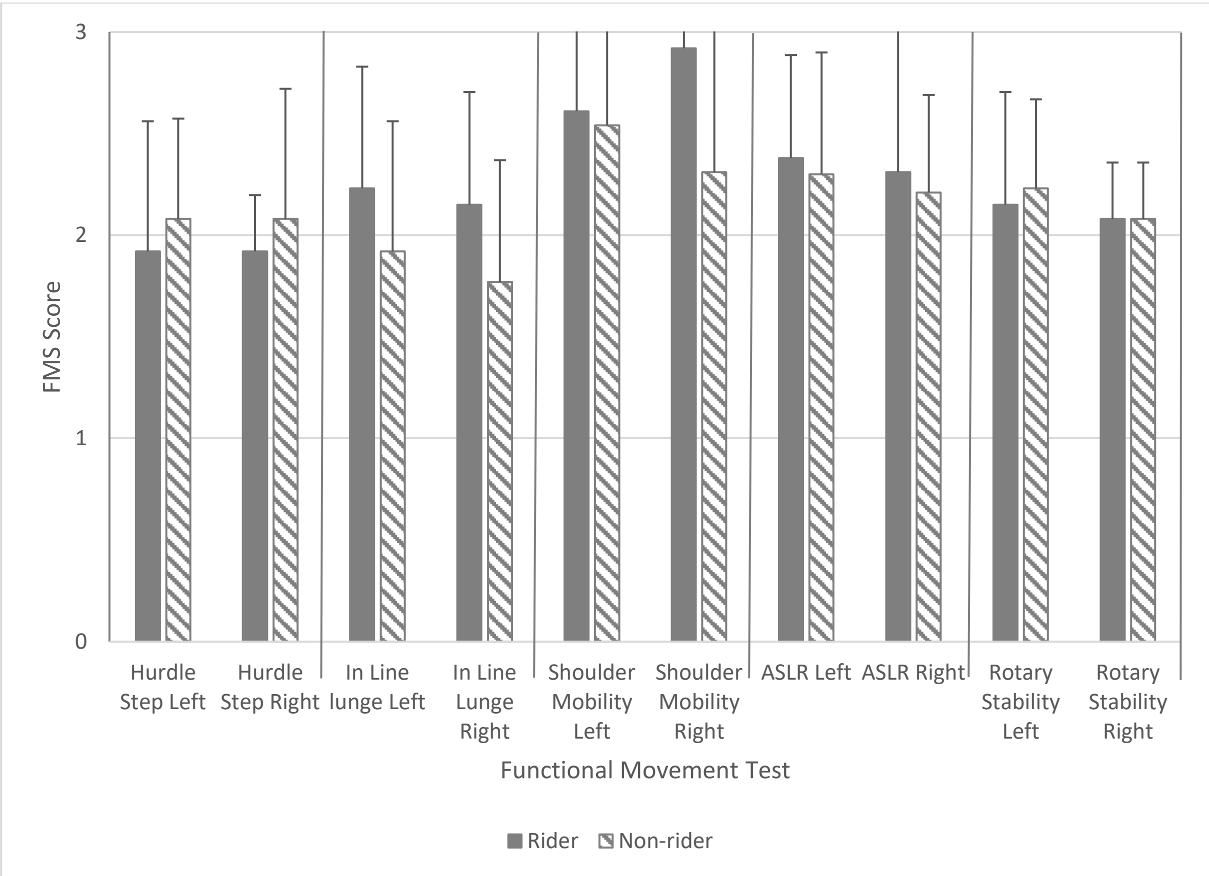

Figure 2. Mean left and right scores for functional movement screen.

Discussion

The purpose of this study was to determine FMS scores in a sub-population of female horse-riders based upon reports of a high prevalence of pain, (Kraft, 2007; Lewis, 2017), and asymmetry (Symes and Ellis, 2009; Hobbs *et al.*, 2014) within horse riders.

As an activity, horse riding has previously been identified as having high risk of injury, with it being regarded as more dangerous than rugby, American football and motor sports (Norwood *et al*., 2000; Sorli, 2000). Most riding injuries occur from falling off the horse resulting in traumatic injuries such as fractures, contusions and concussions (Ball *et al.*, 2007; Mayberry *et al.*, 2007). Overuse injuries and chronic pain, particularly back pain in riders have also been well documented (Kraft, 2007; Lewis, 2017; Lewis *et al.*, 2018). Injury or pain associated with an injury can result in poor performance, time off, retirement and severe injuries often have life changing consequences (Lewis *et al.*, 2018). Many injuries are likely to be the result of physiological fatigue or weakness but this link has not fully been established in horse-riding activities, although well documented in other sports. It is important to be able to identify riders at risk of injury through screening mechanisms so that preventative measures such as strength and conditioning programmes, ergonomics, and training practices can be designed and adopted.

According to Kiesel *et al.* (2007) and O'Connor *et al*. (2011), a composite FMS score of 14 and lower, is a primary indicator of risk of injury. Compared to the inactive non-rider group, the rider population demonstrated a significantly reduced risk of gaining an at risk score of 14 and lower, as seen with an odds ratio of 0.67. A non-rider is a 1.5 times more likely to be at risk of an injury based on their composite FMS score. This suggests that horse riding is beneficial to functional movement patterns despite the degree of difference between the groups being small (albeit riders positively shifted compared to the critical score of 14) and the mean FMS scores not being statistically significantly different. Whilst suggesting regular recreational horse riding (more than 3 times per week) could reduce an individual's chance of injury these results do not indicate that it significantly improves functional movement. Recreational horse riding is considered moderate intensity, however physiological responds increase in competitive equestrian sports, with cross-country and jumping considered high intensity (Douglas, 2012). Further research is therefore needed to test FMS in horse riders regularly competing in these disciplines.

FMS test results have been described in many other populations, including distance runners (Loudon *et al*., 2014), professional football players (Kiesel, 2011), young and active populations (Schneiders *et al.*, 2011), and military personnel (Lisman *et al.* 2013). It is pertinent to establish FMS patterns specific to individual groups of athletes to understand how sports specific demands may influence movement patterns. In this study composite scores for a female collegiate population of horse-riders was 14.15 ± 1.9. This is lower than what has been established for long distance runners (Loudon 2015), professional footballers (McCall *et al.*, 2014), normative values for young females (Schnieders *et al.*, 2013) and for an active population (Perry, 2013). Whilst the differential FMS score of 14 indicates a general predisposition to increase injury risk, it would be interesting to identify whether there was a clear relationship between FMS score and injury during different equestrian activities.

Whilst individual mean composite scores showed a shift in distribution around the critical score of 14 there were no statistical significant differences between medium scores of the two groups, however it is worth considering where this shift is occurring to inform future investigations. In particular shoulder mobility and inline lunge demonstrate high variability, and individuals differed within the rider group and when compared to the non-rider group. The rider participants in this study scored greater scores in the right shoulder mobility test than non-riders. The shoulder mobility test examines shoulder range of motion, scapular motion and thoracic spine mobility. This trend was also seen in the study of Schneiders *et al.* (2013).

The in-line lunge assesses bilateral stability and mobility of the trunk, hips, knees and ankles. It challenges the body's trunk and lower extremities to resist rotation and lateral flexion to ensure appropriate alignment in all three planes. Alexander (2014) points out that trunk rotation to the right was a common postural characteristic in riders and that trunk rotation asymmetry deviates pressure away from the central position in the saddle producing uneven weight through the pelvis. Asymmetric performance in the in-line lunge can be a result of many factors such as hip limitations of either legs, adductor and abductor tightness or weakness or limitations in the thoracolumbar spine. It is important to further investigate the cause in each individual client, but a trend for this movement scoring asymmetric is apparent in riders. Increased iliac crest height to the right has been reported with time spent riding in previous literature (Hobbs *et al.*, 2014) and authors had suggested that the causal factor may be greater muscle stiffness and development on the right side would limit lateral bending to the left. Symes and Ellis (2009) also report this right hip limitation and blocking of movement to the left during actual riding. This might also explain the lower scores shown by riders in the rotary stability to the left.

Asymmetry during riding is not just related to posture. Differences in rein tension between left and right hands have also been reported (Kuhnke *et al.*. 2010). It appears this right side asymmetry may be attributed to hand dominance and grip strength (Hobbs *et al.*, 2014) used during daily activities and potentially exacerbated in this horse riding population due to the daily physical tasks associated with owning and riding horses such as stable work. This further suggests that differential left-right muscle recruitment pattern is being adopted, maybe a precursor for asymmetrical shoulder height (Hobbs *et al.*, 2014). This may account for enhanced right shoulder mobility within this population.

Knutson (2005) suggests leg length inequality (LLI) contributes to functional and anatomical asymmetry as it can cause both pelvic and thoracic girdle rotation leading to axial rotation. The pelvic tilt imposed by LLI may impose bilaterally unequal stresses in the hip and the knee joints, a plausible aetiological factor in a variety of overuse injuries (McCaw, 1992) resulting in lower back and hip pain (Friberg, 1993; Sharpe, 1983; McCaw, 1992). A tilted pelvis shifts the line of action of the centre of gravity away from the hip joint centre on the side of the long limb. The greater muscle activity necessary to compensate for the shift could increase the magnitude of the internal joint force, which may explain right hip limitation in the riding group. Interestingly between 53-75% of the overall human population have a longer right leg, average magnitude of difference of LLI is reported between 2.4mm and 6.8mm, with individual differences reported exceeding 30mm (Knutson, 2005).

It is likely that hip limitation also affects restriction in left lateral bending reported by Hobbs *et al.*, (2014) and Symes and Ellis (2009). Limitation in the hurdle step test may have many causal factors, including weak hip extensors (glutes), flexor and adductor/abductor tightness, weakness in left glutes and tightness of left quads, which can result in poor thoracolumbar stability (Bishop *et al.*, 2015). Asymmetrical movement patterns in this test were seen in both populations.

Hobbs *et al.*, (2014) concluded that axial rotation to the left and asymmetric shoulder height was attributed to muscle development and stiffening on the right side of a rider's body and our data is supportive of that supposition. This asymmetry will undoubtedly effect the rider's ability to control and communicate with the horse. A balanced rider with aligned posture will be easier for the horse to support (De Cocq *et al.*, 2009; Pelham *et al.*, 2010; Clayton *et al.*, 2017; Guire *et al.*, 2017) whereas a rider that is asymmetric will find it difficult to apply and release appropriate aids (Alexander *et al.*, 2014). This may lead to the horse becoming confused regarding the task and may display adverse behaviours that are associated equine welfare issues (McGreevy and McLean, 2007; Goodwin *et al.*, 2009).

Asymmetry has clinical relevance, as an increased prevalence of pain has been reported in riders with asymmetrical postural development and as number of years riding and competitive level increases (Hobbs *et al.*, 2014). Chronic pain in elite riders during competition was reported to be as high as 100% in female riders (Lewis & Baldwin, 2017), and 76% of pain was reported to be lower back pain (Lewis & Kennerley, 2017). Asymmetry is one aetiological factor that contributes to back pain (Nadler *et al.*, 2000). This asymmetry is altered by the distribution and magnitude of mechanical stress placed on the body whilst riding which could result in pain. To date, there is no research that links FMS scores with pain or injury in horse riders despite FMS successfully being used as a tool for predicting risk of injury and development of pain in other sports (Cook *et al.*, 2006).

FMS is used in an attempt to gain a picture of movement quality that challenges mobility through the key structures such as ankles, hips and thoracic spine (Bishop *et al., 2015).* However, it has received some criticism, as it does not assess dynamic movement performed at speed or movement quality under load. Therefore does not fully predict physical performance measures such as acceleration, power or agility (Bishop *et al., 2015;* Bishop *et al., 2016).* Whilst equestrian sport lacks the need to evaluate some of these parameters, high demands are placed on the rider to be able to control their body in terms of acceleration of body segments particularly during jumping, (Nankervis *et al.*, 2015). Patterson *et al.*, (2010) highlighted the need for the rider to limit the acceleration or movement of their head on landing. The rider is forced to maintain their balance through weight bearing via the legs only as opposed to the pelvis and legs as seen in the dressage position, a closed hip and thigh angle and a forward trunk position (Nankervis *et al.*, 2015; Douglas *et al.*, 2012; Patterson *et al.*, 2010). Nankervis *et al.* (2015) also highlighted the repetitive nature of the jump position suggesting riders make changes to their upper body position prior to take-off and require strong 'core' anatomy to enable the torso to return quickly to equilibrium after perturbation upon landing. Thus the FMS with added load and/or speed may reflect both movement capacity and injury risk in riders in a more accurate manner (Bishop *et al., 2016).*

Limitations

The sample was convenience based and a small sample of thirteen female horse riders that attended an equestrian college and were eligible to participate within this study recruited. Competitive level, discipline, years spent riding and additional training load were not accounted for within this preliminary study but could be considered in future studies. The current study has established and corroborated reports that riders have asymmetric movement patterns, and future research should consider exploring the role of the FMS as a screening tool in horse riders.

Conclusion

This study highlights that composite FMS scores found in a small purposeful sample of female collegiate horse-riders indicate a lower risk of injury than in the non-rider population. However, the composite FMS scores were lower than those reported in other sports, suggesting some riders may be at risk of injury. The FMS scores showed that riders scored differently across the tests demonstrating asymmetric movement patterns potentially limiting left lateral movement patterns. Limited left lateral movement patterns have been observed in riders in other studies. Asymmetry has an impact on equestrian performance and given the duration of a rider's career, which may span four decades, highlights the importance of regular functional movement screening to the individual rider. Such findings can be used to develop individual axillary training programmes (both on and off the horse), to improve functional movement and targeted injury prevention. Further research to establish normative scores for the wider horse riding population based on discipline, level and age could inform the development of future training to minimise the risk of asymmetry and injury.

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