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1 **A Preliminary Study Investigating Functional Movement Screen Test Scores in Novice**
2 **and Advanced Female Show Jumping Riders**

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8

9 **Abstract**

10 *The functional movement screen (FMS) is an easily administered and non-invasive tool to identify areas*
11 *of weakness and asymmetry during specific exercises. FMS is a common method of athlete screening in*
12 *many sports and is used to ascertain injury risk, but has to be used within an equestrian population. The*
13 *aim of this study was establish FMS scores for Novice and Advanced Female Show Jumping Riders, to*
14 *inform a normative data set of FMS scores in horse riders in the future.*

15 *Twenty-two female show jumping horse riders (mean age 21.5 yrs.). Twelve riders competing at 80cm*
16 *and below were the 'novice' group and ten riders in the 'advanced' group competing at 125cm, were*
17 *assessed based on their performance on a 7-point FMS (deep squat, hurdle step, in-line lunge, shoulder*
18 *mobility, active straight leg raise, trunk stability and rotary stability). The mean composite FMS scores*
19 *(\pm s.d.) for the novice rider group was 12.08 ± 2.7 and for the advanced riders was 14.08 ± 1.77 . There*
20 *was a statistical significant difference in median FMS composite scores between the novice show*
21 *jumping rider and advanced show jumping rider groups (Mann-Whitney U test, $p=0.004$). One hundred*
22 *percent of novice show jumping riders and 50% of advanced show jumping riders scored ≤ 14 , indicating*
23 *that a novice rider is 2 times (O.R.) more likely to be at increased risk of injury compared to advanced*
24 *riders.*

25 *Advanced show jumping riders scored higher than novice riders but both groups scored lower than seen*
26 *in other sports suggesting some show jumping riders may be at risk of injury. Riders' FMS scores*
27 *demonstrated asymmetric movement patterns potentially limiting left lateral movement. Asymmetry has*
28 *a potential impact on equestrian performance, limiting riders' ability to apply the correct cues to the*
29 *horse. The findings of such screening could inform the development of ancillary training programmes*
30 *to correct asymmetry pattern and target injury prevention.*

31

32 **Keywords: Show Jumping, equestrian, functional movement screen, injury, asymmetry**

33

34 Introduction

35 Functional movement is the ability to produce and maintain a balance between mobility and stability
36 along the kinetic chain while performing fundamental patterns with accuracy and efficiency (Chorba et
37 al., 2010), Muscular strength, flexibility, endurance, coordination, balance, and movement efficiency
38 are components necessary to achieve functional movement which is integral to performance and sport-
39 related skills. Effective performance in Equestrian sports is reliant on the rider maintaining balance and
40 posture in order to be able to administer predictable cues (aids) to the horse. The rider aims to maintain
41 a straight line through the ear-shoulder-hip-heel, with the pelvis in the neutral position and a controlled
42 upright trunk position adapting to the movement of the horse (Guire *et al.*, 2017; Hobbs *et al.*, 2014;
43 Nevison *et al.*, 2013; Douglas *et al.*, 2012; Lovett *et al.*, 2005). The Olympic discipline of show jumping
44 requires the horse and rider to negotiate a course of 12-20 knock able fences. The activity of jumping
45 requires the rider to alter or adjust their position by adopting a forward seat in order to cope with the
46 increased mechanical forces involved. During jumping, the rider closes the hip and thigh angle and
47 moves the trunk into a more forward position. In order to maintain their balance through the jumping
48 phase the rider's weight is absorbed by the legs, as opposed to pelvis and legs as seen in the regular
49 riding position (Nankervis, *et al.* 2015; Douglas, *et al.* 2012; Patterson, *et al.*, 2010). This adjustment in
50 position requires a great deal of control of the body segments, as the rider has to deal with acceleration
51 forces from the horse particularly on landing (Patterson, *et al.*, 2010). If the rider is unable to maintain
52 the desirable position then they are less likely to be able to control their body movements, administer
53 repeatable predictable cues to the horse and are increased risk of losing their balance or causing
54 undesirable behaviours in the horse.

55 Physical screening of athletes is commonplace in many sports to identify areas of weakness or functional
56 insufficiencies. Screening can inform coaches and physiotherapists to actualize their interventions to
57 enhance performance and prevent injuries. The British Equestrian Federation's Long Term Participant
58 Development model suggests that riders' body alignment and functional stability patterns should be
59 regularly tested, yet a standardised, quantitative and valid measure has yet to be fully investigated within
60 this population.

61 The Functional Movement Screen (FMS) is a simple measure to identify asymmetry in a person's basic
62 functional movements. It was designed to assess muscle flexibility, strength, imbalances and general
63 movement proficiency using a range of performance tests. It also identifies deficits related to
64 proprioception, mobilisation, stabilisation and pain within the prescribed movement patterns (Cook *et*
65 *al.*, 2006). It is a screening process growing in popularity due to it being a rapid, non-invasive measure
66 to identify potential injury risk (Cook *et al.*, 2006). The screen consists of seven different functional
67 movements that assess trunk and core strength and stability, neuromuscular coordination, asymmetry in
68 movement, flexibility, acceleration, deceleration, and dynamic flexibility (Peate *et al.*, 2007). The FMS
69 measures the quality of the movement based on specific criteria that allow the evaluator to use
70 quantitative values for the movement on a scale of 0–3. The FMS focusses on the efficiency of
71 movement patterns rather than the quantity of repetitions performed. It has been used as a tool for injury
72 prevention (Kiesel *et al.*, 2007; Kiesel *et al.*, 2011) and composite scores of 14 or below has proven to
73 be a valid indicator of injury risk among elite athletes. Research also indicates that the FMS
74 demonstrates moderate-to-excellent inter- and intra-rater agreement for most of the assessment protocols
75 (Leeder *et al.*, 2013; Shiltz *et al.*, 2013).

76 Lewis *et al.* (2019) used the FMS to test female colligate riders and established a mean composite score
77 of 14.15 ± 1.9 , suggesting that this population maybe be at risk of an injury. Riders are at risk of acute
78 injuries whilst handling horses, as a result of falling off the horse when riding (Whitlock, 1999; Sorli,
79 2000; Moss *et al.*, 2002) and is considered one of the most dangerous sports with a hospital rate of 49
80 hospital visits for every 1000 hours of riding (Sorli, 2005). Long term injuries resulting in chronic
81 pain is seen in 76-100% of riders (Kraft *et al.*, 2007; Lewis, 2017; Lewis *et al.*, 2018) therefore the use
82 of a screen tool to identify poor functional movement that may result in injury such the FMS may be
83 useful in the equestrian population. Although equestrian sports science is an emerging field, evidence-
84 based data on discipline-specific screening are still limited in the equestrian population. Therefore, the
85 aim of this study is to establish FMS scores for novice show jumping riders compared to advance show
86 jumping riders.

87

88 **Methods**

89 *Participants*

90 Twenty-two female show jumping riders took part in this study (mean age 21.5 yrs.). The participant
91 criteria were riders competing at 80cm and below will integrate the ‘novice group’ and riders competing
92 at 125cm and above will integrate the ‘advanced group’. Participants were a convenience sample of
93 volunteers that met the inclusion criteria. Inclusion criteria required all participants to be at least eighteen
94 years of age, injury free and not experiencing pain at the start of the protocol. The experimental protocols
95 received Institutional Ethics Committee Approval and informed written consent was obtained from all
96 participants.

97 *Testing Procedures*

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

104

105 *Functional Movement Screen*

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

109

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

119

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

134

135 *Statistical Analyses*

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

141
 142 **Results**

143 The mean composite FMS scores (\pm SD) for the novice group was 12.08 ± 2.7 ; and for the advanced
 144 show jumping rider group was 14.08 ± 1.77 (Figure 1). There was a significant difference for FMS
 145 composite scores between the novice group (12.08 ± 2.7) and advanced (14.08 ± 1.77) groups (Mann-
 146 Whitney U test, $p = 0.004$). One hundred percent of novice riders and 50% of advanced riders scored ≤ 14 ,
 147 indicating a risk of injury (Table 1) with an odds ratio of 2:1 in novice riders: advanced riders. A novice
 148 rider is two times more likely to be at risk of an injury based on their composite FMS score.

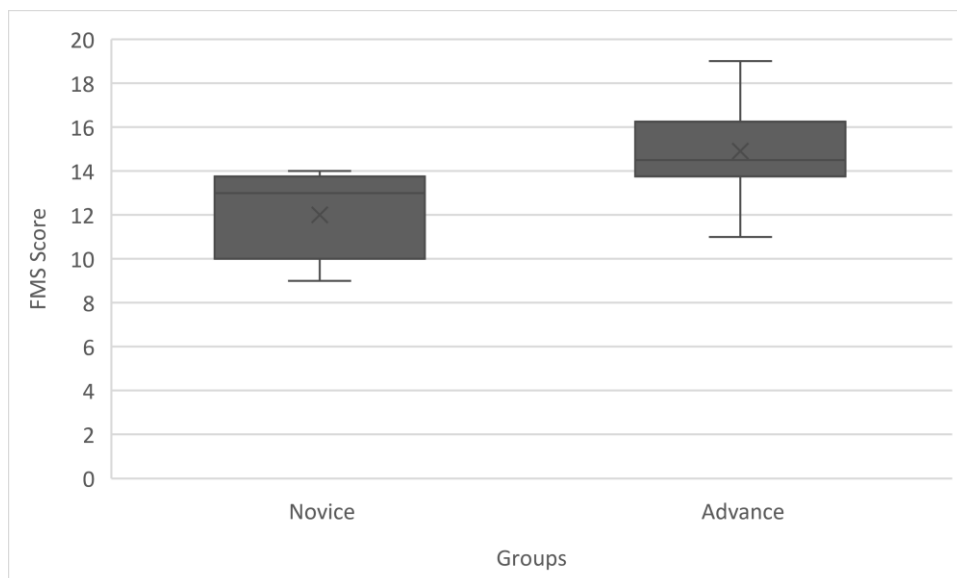
149 Table 1. A comparison of Functional Movement Screening composite scores for a group of novice
 150 show jump riders compared to a group of advanced show jump riders

151

	Number of Participants (n)	Mean composite score	Range of scores	Number of scores ≤ 14	Number of scores >14	Odds ratio
Novice Rider	12	12.08	18-14	12(100%)	0 (0%)	Ad Rider: Nov rider 2 : 1
Advanced Rider	10	14.80	11-19	95(50%)	5 (50%)	

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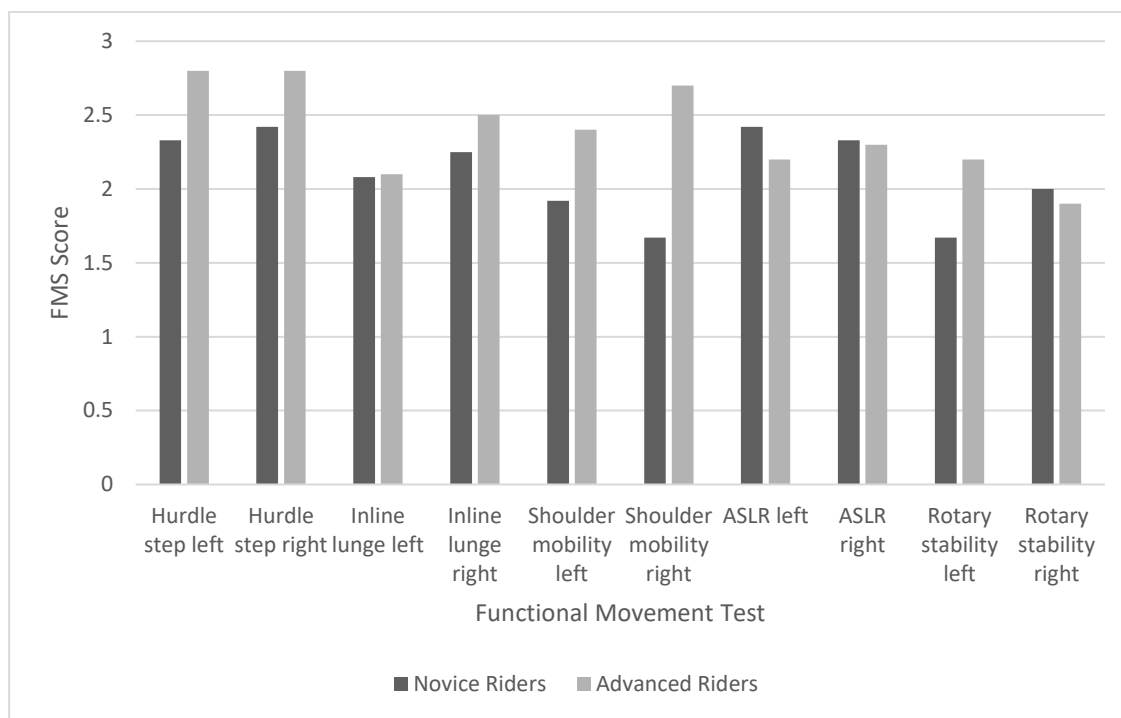
156 Figure 1: Cumulative functional movement scores for the Novice and Advanced show jumping riders

157

158 FMS for individual exercises (Figure 2) showed no significant difference between the two groups except
 159 Hurdle Step Left leg ($p=0.032$), Shoulder Mobility Right arm ($p=0.004$) No significant difference was
 160 seen in absolute asymmetry between riders and non-riders (Mann-Whitney U test, $n=23$, all $p>0.05$).

161

162



163

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

165

166 Discussion

167 The purpose of this study was to determine FMS scores in a sub-population of female show jumpers
 168 based upon reports of a high prevalence of pain, (Kraft, 2007; Lewis, 2018), and asymmetry (Symes
 169 and Ellis, 2009; Hobbs *et al.*, 2014) within horse riders.

170 FMS test results have been described in many other populations, including distance runners (Loudon *et al.*,
 171 2014), professional football players (Kiesel, 2011), young and active populations (Schneiders *et al.*,
 172 2011), and military personnel (Lisman *et al.* 2013). It is pertinent to establish FMS patterns specific to
 173 individual groups of athletes to understand how sports specific demands may influence movement
 174 patterns. In this study composite scores for novice show jumping riders was 12.08 ± 2.7 ; and for the
 175 advanced show jumping riders was 14.08 ± 1.77 . This is lower than what has been established for all
 176 other populations found in current literature (Loudon 2015; McCall *et al.*, 2014; Schnieders *et al.*, 2013;
 177 Perry, 2013; Lisman *et al.* 2013; Kiesel, 2011), including colligate horse riders (Lewis *et al.*, 2019)
 178 where a score of 14.12 was found. Based on the composite scores in the current study novice show
 179 jumping riders double their risk of an injury compared to advanced show jumping riders. Whilst the
 180 differential FMS score of 14 indicates a general predisposition to increase injury risk, it would be
 181 interesting to identify whether there was a clear relationship between FMS score and injury during show
 182 jumping.

183 Horse riding is regarded as one of the most dangerous sports due to the high numbers of injuries (Ekberg
 184 *et al.*, 2011) and this may explain the low composite scores. However, research concludes that riders are
 185 at risk of acute injuries whilst handling horses or as a result of falling off the horse when riding

186 (Whitlock, 1999; Sorli, 2000; Moss *et al.*, 2002) there is no evidence to suggest these acute injuries are
187 as result of poor functional movement patterns. The hospitalisation rate for equestrian activity is 49
188 hospital visits for every 1000 hours of riding (Sorli, 2005). Ball *et al.*, (2009) identified that over half of
189 riders that had been hospitalized due to an acute riding injury, experienced chronic physical difficulties
190 following their accident including chronic pain, weakness, decreased balance, headaches, limited use of
191 limbs which may affect functional movement. Overuse injuries can be caused by the repetitive
192 movement patterns experienced during riding and the repetitive of riding and nature of tasks required to
193 care for horses e.g. mucking out. Horse-riders have been reported as frequently having an asymmetric
194 posture (Symes and Ellis, 2009; Hobbs *et al.*, 2014), which may explain the low functional movement
195 scores seen in the show jumping riders. As such they are at risk of spinal instability, contributing to
196 overuse injury and inevitably leading to back pain (Al-Eisa *et al.*, 2006; Symes and Ellis, 2009; Lewis,
197 2017; Lewis *et al.*, 2018). One of the most prevalent areas of pain in the riding population is back pain
198 (BP), with a reported prevalence of 86% - 100% compared to 33% in non-riders (Lewis *et al.*, 2018;
199 Lewis and Kennerly, 2017; Kraft 2009). No rider in the current study was unable to complete any of the
200 tests due to serve pain (producing a score of 0), low or moderate levels of pain, which may have an
201 influence on the movement pattern was not recorded in this study but the relationship between pain and
202 functional movement is worthy of further research.

203 Within the individual tests the shoulder mobility hurdle step and inline lunge test demonstrate high
204 variability, and individuals differed within the novice group and when compared to the advanced rider
205 group. The advanced participants in this study scored greater scores in the right shoulder mobility test
206 than novice riders. The shoulder mobility test examines shoulder range of motion, scapular motion and
207 thoracic spine mobility. This trend was also seen in the study of Lewis *et al* (2019) and Schneiders *et*
208 *al.* (2013). The in-line lunge assesses bilateral stability and mobility of the trunk, hips, knees and ankles.
209 It challenges the body's trunk and lower extremities to resist rotation and lateral flexion to ensure
210 appropriate alignment in all three planes. Alexander (2014) points out that trunk rotation to the right was
211 a common postural characteristic in riders and that trunk rotation asymmetry deviates pressure away
212 from the central position in the saddle producing uneven weight through the pelvis. Asymmetric
213 performance in the hurdle step and in-line lunge can be a result of many factors such as hip limitations
214 of either legs, adductor and abductor tightness or weakness or limitations in the thoracolumbar spine. It
215 is important to further investigate the cause in each individual rider, but a trend for this movement
216 scoring asymmetric is apparent in riders. Increased iliac crest height to the right has been reported
217 (Hobbs *et al.*, 2014) and authors had suggested that the causal factor may be greater muscle stiffness
218 and development on the right side would limit lateral bending to the left. Symes and Ellis (2009) also
219 report this right hip limitation and blocking of movement to the left during actual riding. Hobbs *et al.*,
220 (2014) evaluated symmetry whilst riding and showed riders with a greater number of years' experience,
221 or competing at a higher level, showed significantly greater postural asymmetries than those with less
222 experience but off horse FMS scores were lower in the novice scores compared to advanced riders in
223 this study, so further evaluation of riding asymmetry and FMS asymmetry is needed.

224 Athletes often utilize compensatory movement patterns to achieve performance. However, these
225 inefficient movement strategies may reinforce poor biomechanical movement patterns during typical
226 activities, resulting in injury (Chorba *et al.*, 2010). Injury and pain can result in poor performance, time
227 off, retirement and severe injuries seen in equestrian sports, often have life changing consequences
228 (Lewis *et al.*, 2018). It is important to be able to identify riders at risk of injury through screening
229 mechanisms so that preventative measures such as strength and conditioning programmes, ergonomics,
230 and training practices can be utilized. Research has demonstrated the importance and contributions of
231 core stability in producing efficient trunk and limb movement allowing for the generation, transfer, and
232 control of forces or energy during integrated kinetic chain activities. During whole-body movement, the
233 core muscle groups (i.e., transversus abdominis, multifidus, rectus abdominis, and oblique abdominals)
234 are activated before any limb movements. Highlighting the importance of these core muscles in
235 functional movement. This core stability is also key to the rider position as the rider requires stabilization
236 and isometric contraction of the back and core muscles (Terada *et al.*, 2004; Terada, 2004), damage to
237 these muscle groups caused by repetitive strain can result in chronic LBP (Shepard, 1997). Poor
238 endurance of the hip extensor muscle (*Gluteus maximus*) and hip abductors (*Gluteus medius*) has also

239 been previously noted in individuals suffering with LBP (Nadler, 2000; Kankaanpaa *et al.*, 1998;
240 McGill, 1997). This suggests that weakness in these muscle groups in connection with LBP may have
241 an impact on the rider maintaining a correct position (Lewis and Kennerly, 2017; Lewis *et al.* 2018).
242 Thus, a strength and conditioning programme focused on developing the ‘core’ could improve the FMS
243 scores in a show jumping riders, reducing injury risk, in turn improve the riders’ position (Hampson &
244 Randle, 2015) and ultimately show jumping performance.

245 *Limitations*

246 The sample was convenience based and a small sample of twenty-two female show jumping riders that
247 were eligible to participate within this study recruited. Additional training load were not accounted for
248 within this study but could be considered in future studies. The current study has established and
249 corroborated reports that riders have asymmetric movement patterns, and future research should
250 consider exploring the role of the FMS as a screening tool in horse riders.

251 **Conclusion**

252 This study highlights that composite FMS scores found in a small purposeful sample of show jumping
253 riders indicate a higher risk of injury in novice show jumping riders compared to advanced show
254 jumping riders. However, the composite FMS scores were lower than reported in other sports and
255 collegiate aged riders, suggesting some show jumping riders may be at risk of injury. The FMS scores
256 showed that riders scored differently across the tests demonstrating asymmetric movement patterns
257 potentially limiting left lateral movement patterns. Limited left lateral movement patterns have been
258 observed in riders in other studies. Asymmetry has an impact on equestrian performance and given the
259 duration of a rider’s career, which may span four decades, highlights the importance of regular
260 functional movement screening to the individual rider. Such findings can be used to develop individual
261 axillary training programmes to improve functional movement and targeted injury prevention. Further
262 research to establish normative scores for other horse riding populations based on discipline, level and
263 age could inform the development of future training to minimise the risk of asymmetry and injury.

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