

## **Generation of domains for the Equine Musculoskeletal Rehabilitation Outcome Score: Development by Expert Consensus**

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1 Article

# 2 Generation of domains for the Equine 3 Musculoskeletal Rehabilitation Outcome Score: 4 Development by Expert Consensus

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9 **Simple Summary:** Within rehabilitation, measurements taken before, during and after treatments  
10 are used to judge patient progress and the effectiveness of prescribed treatments. To know which  
11 measurements to use for a given health conditions, practitioners must have knowledge of what  
12 should be measured, which measurement tools are available and accurate, alongside what they  
13 intend to measure. Composite outcome measures (OMs) are tools which use grouped  
14 measurement tests to monitor patient progress; they have been tested for a variety of human and  
15 canine conditions but none have been designed or tested for use in physical rehabilitation in horses.  
16 This study asked leading equine veterinarians, physiotherapists and researchers which measures  
17 should be included in an OM for use in the rehabilitation of horses. Using a process to evaluate  
18 agreement, ten areas of measurement were included in the final model: lameness, pain at rest, pain  
19 during exercise, behaviour during exercise, muscular symmetry, performance/functional capacity,  
20 behaviour at rest, palpation, balance and proprioception. Existing reliable tests used to measure  
21 these areas were evaluated and potential new measures discussed and now should be taken forward  
22 to testing as a composite outcome score to see if they are effective in measuring effectiveness of  
23 treatment.

24 **Abstract:** Outcome measures (OM) are a requirement of professional practice standards in human  
25 and canine physiotherapy practice for measurement of health status. Measures such as pain and  
26 functional capacity of specific regions are used to track treatment impact and can be used to develop  
27 optimal management strategies. To achieve comparable patient care in equine physiotherapy, OMs  
28 must be incorporated into practice, however no reliable and valid OMs exist for equine  
29 rehabilitation. This study utilised the experience and opinion of a panel of experts working in the  
30 equine rehabilitation sphere to gain consensus on the core areas (domains) to be included in a model,  
31 to lead to an OM scale for horses undergoing rehabilitation. The Delphi method and content validity  
32 ratio testing was used to determine agreement with domains reaching the critical value required for  
33 inclusion. The expert panel agreed ten domains to be included in the OM scale: lameness, pain at  
34 rest, pain during exercise, behaviour during exercise, muscular symmetry, performance/functional  
35 capacity, behaviour at rest, palpation, balance and proprioception. An OM with these domains  
36 would provide a holistic objective assessment tool which could be used by equine rehabilitation  
37 professionals in clinical practice.

38 **Keywords:** Equine; Physiotherapy; Outcome Measures; Rehabilitation; Delphi method

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## 41 1. Introduction

42       Physiotherapy is recommended for a number of equine musculoskeletal conditions such as  
43 overriding dorsal spinous processes and thoracolumbosacral pain, soft tissue injuries such as  
44 ligament and tendon injuries and osteoarthritis [1,2]. However, the degree of detail regarding the  
45 specific physiotherapy interventions, such as for treatments including manual therapy [3],  
46 electrotherapy [1] or exercise therapy [4,5], either individually or in combination, varies between  
47 publications ranging from trials, often with low subject numbers to clinical review papers. As a result  
48 equine physiotherapists use this information in combination with their experience and clinical  
49 reasoning to select treatment interventions they consider effective [6]. For example, in rehabilitation  
50 plans for overriding dorsal spinous processes, exercises to encourage ventral flexion to separate the  
51 spinous processes [7] are used in combination with exercises to strengthen the deeper 'core' stability  
52 muscle *multifidus* [8]. For thoracolumbosacral pain, electrotherapy in the form of neuromuscular  
53 electrical stimulation [7,9] or manual therapy [10,11] are commonly applied. However due to  
54 variation in practitioners experience, and the distinct nature of each patient, there are no standardised  
55 practice guidelines for equine rehabilitation. This lack of standardisation places increased emphasis  
56 on the physiotherapists' ability to assess each horse's progress to ensure they meet their duty of care  
57 to the patient despite the current lack of an evidence base to support this decision making [12].

58       A common feature in published studies that include physiotherapy techniques, is a lack of  
59 objectivity when reporting on the outcome (where outcome is defined as '*any identified result arising*  
60 *from exposure to a causal factor or a health intervention*') [13]. Within human orthopaedic research,  
61 Chiarotto et al. [14] suggested that outcomes are inconsistently measured and reported across trials  
62 of health interventions for low back pain in humans [14]. Similarly, in equine research subjective  
63 outcomes (e.g. decisions on success based on horse-owner survey) are reported after surgery for over-  
64 riding dorsal spinous processes [7,15,16] and the treatment of sacro-iliac disease [17]. The lack of  
65 outcome measurement reduces the ability to compare findings between studies and potentially  
66 encourages selective reporting of favourable outcomes [14]. This will impact ongoing practice and  
67 *may* result in confirmation bias when assessing subsequent outcomes, thus placing the patient at risk  
68 of lack of progress, or worse still deterioration of their situation. Given the duty of care that a  
69 physiotherapist has with their patient, this remains an important issue. In human research, to reduce  
70 the heterogeneity of outcome measures (OMs) in clinical trials, there are agreed minimum sets of  
71 outcomes that should be measured by clinicians and reported for a particular health condition [14].  
72 These specific measurement tools or techniques are known as outcome measures and a grouping of  
73 OMs can be used to form a composite outcome score that can then be used to assess the short- and  
74 long-term effect of rehabilitation for the patient [18].

75       OMs have been developed for use in human practice for the measurement of health status and  
76 include measures of pain and functional capacity in specific regions, used to track impact of treatment  
77 and thus the development of optimal management strategies [19]. For sport injuries, the Victorian  
78 Institute of Sport Assessment Scales for patella tendinosis and achilles tendinopathy, and the  
79 Copenhagen Hip and Groin Outcome Score are examples of OMs that have been generated to score  
80 pain, symptoms and physical function [20-22]. For dogs, outcomes can be measured with the Helsinki  
81 Chronic Pain Index, the Canine Brief Pain Index or the Finnish neurological function testing battery  
82 for dogs named the FINFUN [23-25]. These examples of composite OMs for humans and dogs have  
83 face validity, have undergone reliability and validity testing, and are used in clinical practice,  
84 however no composite OMs have been developed for equine physical rehabilitation.

85       To achieve comparable professional practice standards in equine physiotherapy, OMs must be  
86 incorporated into practice [6]. To date, a few equine specific OMs, that measure a single factor in  
87 clinical practice (referred to as objective markers (OBJM)), have been subject to reliability testing but  
88 there are no composite equine OMs. OBJMs include the use of pressure algometry [26,27], manual  
89 palpation scoring [28,29], posture/muscle size measurement from photographs [30], muscle  
90 dimension measurement using a flexicurve ruler [31], range of joint motion using a universal  
91 goniometer [32,33] and evaluation of pain-related behaviour [34]. Despite these studies, the use of

92 OBJM in clinical practice is sparse and clinicians report this being due to the lack of available,  
93 validated and reliable OBJMs [6], suggesting a lack of awareness to the available evidence.. In a recent  
94 survey, equine physiotherapists stressed that OBJMs and OMs need to be simple to use, inexpensive  
95 and relevant to the cases they see [6]. It is unknown which domains clinicians working in the equine  
96 rehabilitation industry would consider valuable to measure and how these could be combined to  
97 generate a composite outcome score specific and relevant for the cases practitioners work with. The  
98 aim of this study was to determine which domains should be measured within equine  
99 musculoskeletal rehabilitation, to develop a globally useful composite outcome score.

100

## 101 2. Materials and Methods

102 The methodology was guided by international best practice guidelines for the development of  
103 patient reported outcome measures [35] and involved iterative stages using a mixed methods  
104 approach that involved a literature review [36] and expert input. The Delphi method of gathering  
105 data was used to gain a convergence of opinion from the invited selection of veterinarians,  
106 physiotherapists and equine researchers located world-wide. The Delphi method, which is an  
107 accepted method for achieving convergence of opinion, was selected as a technique using group  
108 communication from a panel of experts [37]. Using this method, the panel members are able to review  
109 and revise their responses in the stages of the process [38] and the controlled feedback process  
110 provides anonymity to the respondents, which may be a factor in group based discussions [37].

111

### 112 2.1 Delphi step 1

113

114 Via email, 35 subject matter specialists, based in Europe and the United States were invited to  
115 participant in the study based on their expertise in equine rehabilitation. These included: ten equine  
116 veterinary surgeons with greater than 10 years clinical experience, all of whom are published in  
117 equine musculoskeletal health and behaviour research; fifteen UK Chartered Physiotherapists  
118 (Association of Chartered Physiotherapists in Animal Therapy, category A members) with greater  
119 than 10 years equine practice experience; and ten equine research professionals, with an interest in  
120 equine musculoskeletal rehabilitation and performance working in equine higher education  
121 institutes. Consent by participants, to be included in the Delphi process, was gained via response to  
122 the first email in step one, which also confirmed responses would be compiled anonymously.

123

124

125 Once invited to participate each expert was asked to reply with confirmation that they wished  
126 to be included in further rounds of the process and asked to suggest domains to be included. The  
127 term domain was defined as an area of measurement that could be included within an OM for equine  
128 musculoskeletal rehabilitation.

129

130 At this stage the number of survey rounds was not fixed and was to be determined by the degree  
131 of consensus within the panel of experts. We did, however, expect there to be between three and five  
132 rounds with the last providing a final opportunity for the experts to revise their judgments [37].

133

### 134 2.2 Delphi step 2

135

136 An email with a link to a questionnaire (SurveyMonkey, San Mateo, California, USA) was sent  
137 out to those experts that responded positively to being included in the Delphi panel. This stage was  
138 designed to assist selection of the domains that should be included in the final tool termed 'the equine  
139 musculoskeletal rehabilitation outcome score (TEMROS)' with the option to suggest other areas that  
140 could also be included. There were potentially a large range of domains that could be part of the  
141 outcome score, thus to keep the outcome score practitioner friendly, valid and reliable, the number  
142 of domains included needed to be limited by consensus of the Delphi panel. The experts were  
provided with a list of domains collated from the response of the first email round. Within the

143 second questionnaire, each domain required the expert to mark whether the specific outcome was  
144 essential, useful but not essential, not useful or if the expert was unsure if it should be included as an  
145 area of measurement for the purpose of musculoskeletal assessment in a horse undergoing  
146 rehabilitation [39,40].

### 147 148 2.3 Delphi step 3

149 From the responses gained, a content validation process was used to agree to include or discard  
150 items listed as possible domains (Lawshe, 1975) with content validity ratio (CVR) and critical values  
151 used to confirm the level of agreement that exceeds that of chance (figure 1) [40]. Perfect agreement  
152 would result in +1 and perfect disagreement results in a CVR of -1. This process was used to identify  
153 the domains to be included in TEMROS.

$$154 \qquad \qquad \qquad \text{CVR} = \frac{n_e - (N/2)}{N/2}$$

158 Figure 1: Lawshe's (1975) content validity ratio (CVR) where  $n_e$  is the number of essential  
159 members and N is number of panel members [39].

### 160 161 2.4 Delphi step 4

162 The list of domains that met the agreement criteria were emailed to the panel of experts who  
163 were invited to comment on the final selection.

## 164 3. Results

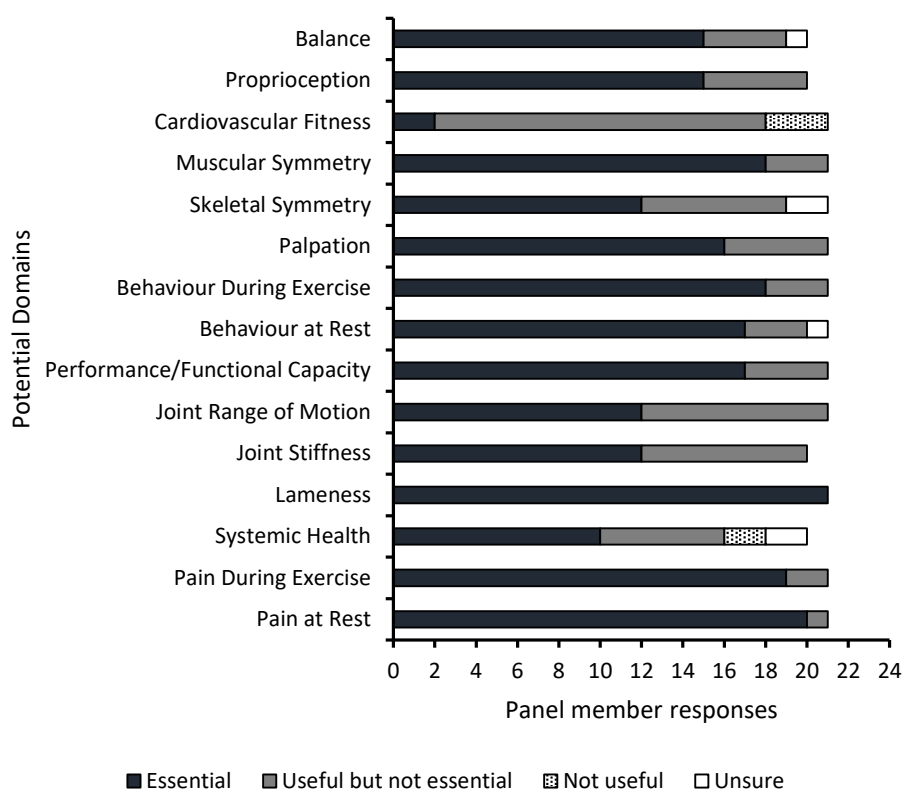
### 165 3.1 Delphi step 1

166 Seven veterinary surgeons, eleven ACPAT Physiotherapists and six equine industry experts  
167 agreed to be included in the Delphi process and fifteen potential domains were suggested. These  
168 fifteen domains were taken forwards to the questionnaire in step 2.

### 169 170 3.2 Delphi step 2

171 The questionnaire was returned by 21 of the 24 experts from step 1 and the data tabulated (Figure  
172 2)

173



174  
175 Figure 2: Expert opinion on domains to be included in an equine musculoskeletal outcome  
176 score.

### 177 3.3 Delphi step 3

178 The critical number required for the proportion in agreement (considering the domain to be  
179 essential) for a panel of 21 members according to Ayre and Scally [40] is 15 (71.4%), with a minimum  
180 CVR critical value of 0.429 [40]. Therefore using content validity ratios the number of possible  
181 domains for inclusion in TEMROS was reduced from 16 to 10. These were, with CVR values provided  
182 in parentheses: lameness (1.00), pain at rest (0.91), pain during exercise (0.81), behaviour during  
183 exercise (0.71), muscular symmetry (0.71), performance/functional capacity (0.62), behaviour at rest  
184 (0.62), palpation (0.52), balance (0.50) and proprioception (0.50). The domains with CVR critical  
185 values less than the required critical value were: joint stiffness (0.20), joint range of movement (0.14),  
186 skeletal symmetry (0.14), systemic health (0.00) and cardiovascular fitness (-0.81).

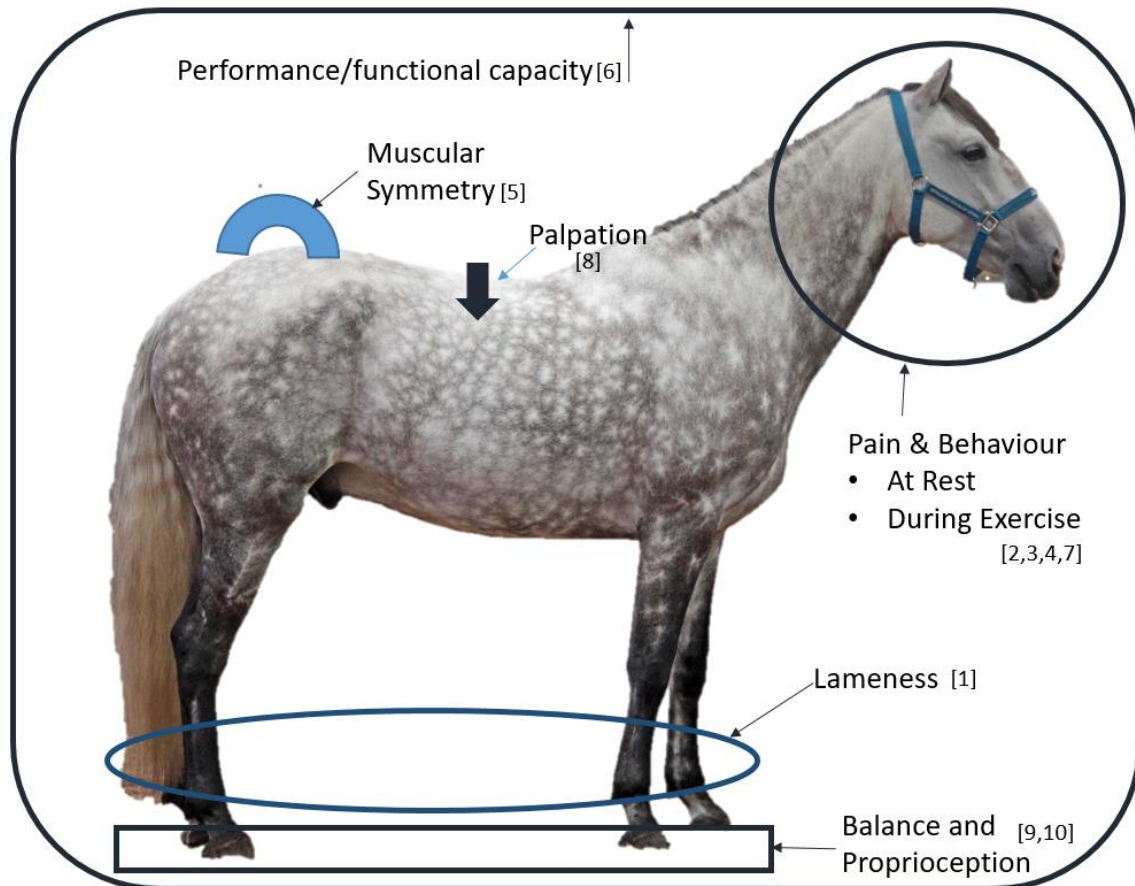
### 188 3.4 Delphi step 4

189 Seven panel members responded to the list of 10 domains positively and there were no further  
190 domains proposed for inclusion. There were three comments that centred on domains that should  
191 not be included. Three experts suggested that systemic health does not need to be measured within  
192 an outcome score, as this should be a pre-requisite for undertaking a rehabilitation programme and  
193 two mentioned cardio-vascular fitness measurement being outside the scope of a musculoskeletal  
194 assessment tool.  
195

## 196 4. Discussion

197 Using expert's experience and opinion, this study aimed to develop a consensus on the domains  
198 to be included in a model for a composite outcome score for horses undergoing rehabilitation. These  
199 data indicate that observational data (e.g. lameness and behaviour due to pain) and hands-on (e.g.  
200 palpation on soft tissue) were considered essential for inclusion within a musculoskeletal OM. The  
201 broad range of domains in this study's model suggests that an outcome score needs to contain a

202 variety of data. Indeed, this approach would provide a holistic view of the status of the horse  
 203 undergoing therapy (figure 3).  
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Figure 3: Ten domains for measurement, as agreed by the expert panel, to be included in outcome score for equine musculoskeletal rehabilitation. In order of highest agreement the domains (with number in square brackets) are: 1: lameness, 2: pain at rest, 3: pain during exercise, 4: behaviour during exercise, 5: muscular symmetry, 6: performance/functional capacity, 7: behaviour at rest, 8: palpation, 9: balance and 10: proprioception.

#### 4.1 Lameness

The highest agreement across the panel was for the inclusion of a lameness measurement within TEMROS. In equine practice lameness is typically evaluated by observing movement asymmetry in trot, however this often presents a challenge especially in horses presenting with low grade lameness [41,42]. For gold standard detection and evaluation, force plates are recommended although these are not used outside the research environment and not practical for clinical assessment, therefore inertial sensor systems are useful where force plate analysis is not practical [43]. In practice, lameness assessment is commonly conducted by a visual gait assessment without technological equipment [41]. Visual assessment, without technological equipment, has been investigated for both intra- and inter-rater reliability. Keegan et al [42] studied the reliability of overground evaluation of lameness to determine if clinicians could agree on whether horses were lame and if so, which was the limb and score for the maximum level of lameness [42]. The American Association of Equine Practitioner (AAEP) scoring method was used, which is a 6 point scale where 0: Lameness not perceptible under any circumstances; 1: Lameness is difficult to observe and is not consistently apparent, regardless of circumstances (e.g. under saddle, circling, inclines, hard surface, etc.); 2: Lameness is difficult to observe at a walk or when trotting in a straight line but consistently apparent under certain circumstances (e.g. weight-carrying, circling, inclines, hard surface, etc.); 3: Lameness is consistently observable at a trot under all circumstances; 4: Lameness is obvious at a walk and 5: Lameness produces minimal weight bearing in motion and/or at rest or a complete inability to move

231 (<https://aaep.org/horsehealth/lameness-exams-evaluating-lame-horse>). Keegan and colleagues [42]  
232 found that agreement of grading mild lameness was low (61.9%), although the agreement of lameness  
233 being present in horses scored greater than 1.5 on the AAEP scale was higher (93.1%) [42]. In addition,  
234 previous studies have shown lower agreement when practitioners assessed videos of lame horses  
235 [44,45,46]. Therefore it is suggested that multiple evaluators should not be used to evaluate lameness.  
236 In contrast to the AAEP score, one prominent equine veterinarian reported that too many horses with  
237 different levels of lameness have to be graded 3 on the AAEP scale and therefore in practice they use  
238 their own scale [47,48]. This recommended scale has 9 categories, where 0 = sound; 2 = mild; 4 =  
239 moderate; 6 = severe; 8 = non-weight bearing. The marked difference is that the grading system is  
240 applied in individual gaits and tests, for instance in a straight line or on a circle, to give a more  
241 accurate picture of the lameness, as it is their consensus that 0-5 represents insufficient grades and  
242 other systems using scores 0-10 consistent of too many options to be useable [47]. Whilst lameness  
243 was the domain which achieved universal agreement (100%), hence it should be included, how  
244 lameness evaluation is integrated remains challenging especially in the presence of bilateral  
245 lameness, lameness occurring only with specific conditions such as under saddle or in the case of an  
246 asymmetric gait that is due to morphology or laterality. The premise of an outcome score for  
247 practitioners is that it should be easy to use in clinical practice, therefore although technology may  
248 be increasingly available [49] whilst it is not yet in every practice or available to non-veterinary  
249 practitioners, a categorical subjective score would need to be included in TEMROS. The exact choice  
250 of grading system requires further study due to the absence of a universally accepted method that is  
251 easy to define, repeatable and can take into account the range of clinical presentations of lameness  
252 [47]. Until this is available physiotherapists should evaluate lameness individually, based on intra-  
253 rater reliability of lameness assessment being more reliable than inter-rater and that agreement  
254 between 'improvement' or 'worsening' in horses seen on multiple occasions is repeatable to use as  
255 an indicator of improvement, irrespective of the absolute score [46].

256

#### 257 *4.2 Pain assessment*

258 Four domains selected related to the assessment of pain: pain at rest; behaviour at rest; pain  
259 during exercise and behaviour during exercise. Whilst crucial to horse welfare, the recognition and  
260 measurement of pain in horses is widely acknowledged to be difficult [50,51] due to pain levels  
261 reported by an observer being subjective and open to bias [52]. Pain has been reported to change  
262 facial expression in mice [53], rats [54] and more recently in horses via the horse grimace scale [50]  
263 and the equine pain face [51]. Both these equine scales have been validated for recording pain at rest  
264 by categorical scoring of facial expression and thus either could be used for the pain and behaviour  
265 at rest domains within TEMROS. The use of pain assessment for chronic, longer term pain conditions  
266 would have to be considered in the context of rehabilitation as this process takes longer than the  
267 duration of pain evaluation in the trials. These scoring systems have been shown to have acceptable  
268 inter-rater reliability for horses with acute pain. It would be of interest to know if veterinary  
269 professionals score similarly to the non-trained carers of horses undergoing treatment. Whether  
270 carers can objectively evaluate pain and not be altered by bias in either direction has not been  
271 reported nevertheless it is important to ensure that accurate pain assessment leads to optimal pain  
272 management throughout the whole course of treatment

273 Pain and behaviour during exercise could theoretically be integrated within TEMROS via  
274 scoring of facial expressions [55] and whole-horse behaviours during in hand and groundwork, and  
275 ridden work [56]. The level of activity that the horse was undertaking at the stage of rehabilitation  
276 would have to be factored into the outcome score, as early phase programmes may prohibit ridden  
277 activity, so pain and behaviour during handling tasks such as leading or ground work would need  
278 to be considered. As well as the task and the environment the assessment occurs in, an additional  
279 element that may alter horse's behaviour is the effect of the handler [57]. Therefore validity of pain  
280 assessment via facial expressions or whole horse behaviours during in-hand and groundwork with a  
281 handler, and in different locations such as an indoor arena or an outside location needs to be studied  
282 further.



283 It is of significant importance to horse welfare that the signs of pain in horses, whether in the  
284 stable or whilst being handled/ridden are considered during assessment. Evaluation of rehabilitation  
285 progress would not be holistic without including monitoring of pain, therefore further studies are  
286 required to test the application of pain assessment methods (e.g. Equine Pain face [51] or the  
287 ethogram for the assessment of pain in ridden horses [56]), specifically to rehabilitation programmes.  
288

#### 289 4.3 Muscle symmetry

290 The need to evaluate muscle symmetry is apparent when considering pathologies such as those  
291 in the region of the sacro-iliac joint, which may result in asymmetric atrophy of the overlying gluteus  
292 medius muscle [58]. Thoracolumbosacral pain can result in thoracic epaxial muscle wastage [7,59]  
293 which anecdotally may be lateralised and therefore asymmetric. Epaxial muscle size can be measured  
294 with ultrasound imaging [8,60,61] but this method may not always be accessible due to cost and its  
295 setting in veterinary or research laboratories. External muscle profile shape can be recorded with a  
296 low cost piece of equipment called a flexicurve ruler and this has been shown to be repeatable in the  
297 thoracic region [31] however the use of a flexicurve has not been reported on in other areas of the  
298 muscular system. The repeatability of a muscle scoring system devised by the authors of a study to  
299 investigate the relationship between thoracolumbar kinematics and muscle tone and tension in  
300 dressage horses found moderate agreement between five assessors (0.60-0.79) [62]. It was suggested  
301 that the muscle score could be used by physiotherapists to identify and monitor muscle development,  
302 however the authors' note the scale was subjective and only applicable to dressage horses. Therefore  
303 if this domain is to be included within TEMROS objective measures need to be further developed for  
304 clinical practice and tested for reliability and validity for horses in all equestrian disciplines, to be  
305 applicable to the possible range of horses undergoing rehabilitation.  
306

#### 307 4.4 Performance/functional capacity

308 Most tests of performance in horses have a strong physiological basis, such as standard exercise  
309 tests which evaluate relative speed and heart rate or blood lactate levels [63,64]. The intensity of the  
310 exercise effort in standard exercise tests, albeit submaximal, may not be appropriate for horses  
311 undergoing rehabilitation. A test of performance and functional capacity would need to be at lower  
312 exercise intensities and personalised to the stage of rehabilitation [65,66]. In human sports medicine  
313 function performance tests are used to evaluate return to play status in footballers [67], muscle  
314 strength and functional performance in recreational athletes following anterior cruciate ligament  
315 reconstruction [68] as well as function in patients with patella tendinosis or achilles tendinopathy  
316 [20,21]. Similarly, in dogs, functional tests are available such as the Canine Brief Pain Index and the  
317 Helsinki Chronic Pain Index [23,54] which include questions on tasks such as how well the dog rises  
318 to standing and willingness to walk or run. A functional score for dogs with neurological conditions  
319 has been tested for inter-rater reliability by seven observers scoring tasks of progressive difficulty  
320 such as standing up from lying, walking in turns or walking stairs [25]. The performance was graded  
321 with a numeric score from 0, indicating the dog cannot perform the task to 4, which represented  
322 normal motor function. No such scores exist in equine assessment but a simple battery of tests could  
323 be devised that included movements such as flexion of the neck [69] and turning small circles [70].  
324 Any such testing procedure would need to be subject to evaluation of face and content validity and  
325 reliability testing similar to the neurological function tests for dogs devised by Boström et al [25].  
326

#### 327 4.5 Palpation

328 The panel agreed that palpation should be included in the proposed composite outcome score  
329 and it was expected that manual palpation would be required as local assessment of soft tissues and  
330 joint margins is commonly undertaken when assessing injury and pain [70]. Response to the manual  
331 palpation can be evaluated in the form of the behavioural response and/or evaluation of localised  
332 short-term change in the tissue being palpated, with a lower threshold to the onset of these responses  
333 indicative of a higher level of pain arising from these soft tissues [26-28,71,72]. Pain sensitivity, as a  
334 subjective experience, is individually variable in humans and based on complex physical and

335 psychological interactions [73]; similarly third-party assessment of pain in animals has found wide  
336 intra-species variation exists as well as reported differences between species [74]. In horses, subjective  
337 judgement of pain thresholds by manual palpation is commonplace [28], therefore the use of  
338 quantitative tools to assess responses to palpation may be preferable to subjective pain assessment  
339 because this allows rating of response with a force output. Pressure algometry (PA) uses a calibrated  
340 pressure gauge to objectively record the threshold the onset of pain in the tissues it is applied on [77]  
341 The PA has been used to evaluate chiropractic interventions for equine thoracolumbar pain [11] and  
342 algometry measurements correlate with palpation scores ( $r = -0.90$ ) [28]. However, reports that  
343 repeated PA application can result in sensitivity or habituation to the PA tool [29,71] could limit their  
344 validity in clinical practice. As an alternative, categorical scoring systems can be used to score  
345 response to manual palpation and use of this form of reporting could be integrated into TEMROS  
346 [9,27-29]. Merrifield-Jones et al [29] used a six-point score, where 0 is described as soft, low tone; 1 as  
347 normal; 2 as increased muscle tone but painful; 3 as increased muscle tone and/or painful (slight  
348 associated spasm on palpation, no associated movement; 4 painful (associated spasm on palpation  
349 with associated local movement, i.e. pelvis tilt, extension response) and 5 as very painful (spasm plus  
350 behavioural response to palpation, i.e. ears flat back, kicking). This score has shown excellent inter-  
351 rater reliability on a small sample of ten riding school horses between three physiotherapists when  
352 assessing epaxial soft tissue (ICC 0.09) [29]. The use of the PA tool, if practitioners were trained, could  
353 provide objective data if habituation and sensitisation were considered but the use of a categorical  
354 scale would provide a cost effective and convenient method of assessing response to palpation.

355

#### 356 *4.6 Balance and Proprioception*

357 The final two domains that reached the minimal critical value for inclusion were balance and  
358 proprioception. The first study to measure balance in horses investigated postural sway using force  
359 platforms demonstrated that the standing horse has small movements of the centre of pressure  
360 resulting from small adjustments of muscle tension, indicating the stability of the quiet standing  
361 horse's centre of mass [75]. Whilst balance has not been measured in relation to musculoskeletal  
362 injury, motion of the centre of pressure does increase with medical sedation administered  
363 intravenously [76]. Signs of ataxia such as trembling, locking and unlocking of joints, weight shifts  
364 and obvious swaying were observed and it could be theorized that injury to one component required  
365 to maintain balance, such as sensory input, motor responses and cognitive processes [75] could have  
366 similar effects. To further examine potential clinical signs from neurological deficits, in relation to  
367 balance, twenty horses were blindfolded whilst stood on a force platform [77]. In these horses,  
368 movement amount and velocity increased, and showed greater within-trial variability when horses  
369 were blindfolded compared to their sighted measurements. Force platforms have been used as a  
370 primary outcome variable to assess the effects of osteoarthritis, surgically induced into the carpal  
371 joint in a group of 16 young horses [78]. Half of the cohort underwent an exercise regime on a water  
372 treadmill from 15 days following the surgery, five days a week for a total on ten weeks. At  
373 reassessment the horses that had been exercised on the water treadmill had significantly improved  
374 static balance control compared to control group of horses with carpal joint osteoarthritis. It should  
375 be noted that whilst these three force plate studies assessed postural sway during stance, gait involves  
376 spinal reflexes that might respond differently to effect balance during locomotion [76] therefore the  
377 results are limited as they cannot directly be translated to balance during gait.

378

379 Proprioception, as a domain listed to be included in TEMROS, does not have any objective  
380 measurement techniques reported for horses. However, postural stability relies on motor  
381 components of the musculoskeletal system to maintain balance and this includes proprioceptive  
382 information. Muscles induce joint motion and are also responsible to stabilising joints during motion  
383 therefore proprioceptive feedback is crucial to balance control [75,78]. Impairment to sensory and  
384 motor components, possibly due to joint injury, could affect postural control and if measured could  
385 also provide a proxy for proprioceptive deficit, but understanding this relationship within the scope  
386 of equine rehabilitation requires further analysis.

387

388 Force platforms could be used to measure balance and proprioceptive changes as a result of  
389 therapeutic interventions, although laboratory-based equipment is required because equine force  
390 platforms are not easily mobile. For clinical practice other methods to measure balance are  
391 necessary. Exercises to challenge balance and activate the trunk core muscles have been suggested as  
392 part of rehabilitation plans [79]. These exercises destabilise the horse by lifting a limb and inducing a  
393 weight transference to the contra- or ipsi-lateral weight-bearing limbs, however they do not have any  
394 form measurement to evaluate their effectiveness. A pressure mat that measures percentage weight  
395 distribution between limbs is available for canine orthopaedic assessment [80] and if a similar  
396 measurement method or a score system could be developed for horses then these positions could be  
397 used as a form of balance evaluation.

398

#### 399 4.7 Limitations to the study

400 The number of experts selected to participate was small and was carried out based on the criteria  
401 (knowledge of research published and industry expertise) of the authors. This could present bias to  
402 the panel however once formed, TEMROS could be presented to the wider equine community for  
403 consideration and content validation. It would have been of benefit to have an understanding of the  
404 rationale for inclusion [81] to allow retrospective analysis of domains chosen. The high levels of  
405 agreement for the domains selected supports the consensus is based on common experience and  
406 practice.

407

408 Although a wide literature search has been completed to map potential reliable and valid  
409 measurement tools/tests to each domain it is possible that there are suitable tests/tools which were  
410 not suggested for inclusion by the panel. An example is thermography which has been used to  
411 measure surface temperature of racehorses' epaxial muscles in response to training [82]. Skin  
412 temperature measurements have not been used to evaluate effects of rehabilitation intervention  
413 however the reducing cost of thermography cameras may allow more horses to be imaged with this  
414 non-invasive and non-ionizing modality, albeit following strict protocols for carrying out and  
415 analysing results [83]. It should be noted that the choices of tests are evaluated in relation to those  
416 considered practical and feasible to use *ex vivo*. To be valid as a measure of rehabilitation outcome,  
417 each domain should have face validity which is a key factor in the development of an efficient OM is  
418 for the score in the absence of any gold standard [13].

419

#### 420 4.8 TEMROS - further development

421 A composite score integrating the above domains takes into account several behaviours and  
422 physiological parameters by including scores for each specific parameter. There are domains that  
423 have various scoring systems or measurement tools, such as lameness and palpation and the final  
424 system/tool which require further testing to be validated. There are also domains where  
425 measurement techniques have yet to be designed for or tested, for instance muscle symmetry and  
426 proprioception, and therefore these areas need further development. Some of the parameters could  
427 be weighted according to perceived significance or they could be graded equally [33] and evaluation  
428 of this requires further development. However, TEMROS has the potential to provide a holistic  
429 assessment which would be relevant to rehabilitation of injury, as the whole horse is undergoing the  
430 rehabilitation not just the condition.

431

## 432 5. Conclusions

433 The Delphi methodology was successfully applied to attain consensus across the selected  
434 international expert panel that there is a need for an outcome measure for equine rehabilitation and  
435 agreement on the domains that such a measure should include. The expert panel agreed that  
436 lameness, pain at rest, pain during exercise, behaviour during exercise, muscular symmetry,  
437 performance/functional capacity, behaviour at rest, palpation, balance and proprioception should be

438 included. The challenge going forward is to combine measures for each of these domains that are  
439 reliable, valid and easy to use in clinical practice. With reliably measured domains, and subsequent  
440 validity testing, TEMROS could provide a composite score that has equine practitioner consensus  
441 that could support clinical practice as well as substantiate treatment choices to improve horse welfare.

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