Objective Measurement in Equine Physiotherapy

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Abstract

Objective measurement should be incorporated into all areas of physiotherapy including within the assessment and treatment of horses, as there is a need to evaluate the effectiveness of treatment intervention objectively. Whilst objective measures are available in a research laboratory setting it appears that in clinical practice mostly subjective methods of recording assessment and reassessment data are used. This article reviews the objective measures currently available to equine physiotherapists for use in clinical practice, beyond those available in a research laboratory setting. Within the literature there are studies reporting the reliability and validity of objective measures for the assessment of pain, gait, posture, range of motion, palpation and muscle size in horses. Whilst these validated objective measurement tools are available, they are not presently used consistently in clinical practice. In addition, the non-verbal nature of the equine patients precludes the use of self-reporting, meaning that there are no reported functional outcome scores possible similar to use with human patients. However the combined use of pain responses, behavioural changes and objective measures collected during clinical assessment, both pre and post treatment, could be useful in practice. Equine physiotherapists should integrate more objective methods of recording data from assessments of horses.

Keywords: Equine, horse, objective, clinical practice, outcome measurement, reliability

Introduction

Equine Physiotherapists work within the team of professionals supporting both elite and leisure horse populations, and are frequently involved in the management of musculoskeletal injuries working in partnership with veterinarians (in some countries) (Tabor, 2018). Within human practice, physiotherapy is an evidence-based profession (Chartered Society of Physiotherapy, 2017) and in order to achieve comparable professional practice standards into equine practice there is a need to justify the intervention applied/physiotherapeutic treatment and evaluate its effectiveness. Therefore Chartered Physiotherapists treating horses need to incorporate objective measures (OM) into clinical practice (Bennell *et al.*, 1998). In the UK the CSP and the Health and Care Professions Council (2013) (HCPC) states registrant (human) physiotherapists *'must be able to assure the quality of their practice. This includes gathering qualitative and quantitative data, participating in audit activity, using appropriate outcome measures and evaluating interventions to ensure they meet service users' needs and changes in health'.* When physiotherapists assess horses their aim is to reach a functional diagnosis that identifies impairments and limitations to physical activities, compared with the veterinary approach which usually would reach a pathoanatomical diagnosis (Goff, 2016; McGowan *et al.*, 2007]. In the UK, according to the Veterinary Act (1966), the responsibility for diagnosis lies with the veterinary surgeon however the clinical reasoning for a both veterinary and physiotherapy assessment are the same (McGowan and Cottriall, 2016) and as such both should include objective measurement within assessment of musculoskeletal conditions.

Patient reported outcome measures (PROM) have been shown to be reliable (repeatable) and valid in human practice (Kyte *et al.*, 2015) with reliability being the extent to which repeated measures yield consistent results, providing stable results that detect change in the actual value and validity being whether the measure actually measures what it is supposed to measure (Randle *et al.*, 2017). Within equine practice it is not possible to use direct PROMSs when assessing outcomes of treatment of horses (Goff, 2016) as horse handlers, owners, riders and trainers report on their observations or judgement of effectiveness of treatment, with their views gathered as part of physiotherapist assessments subjectively. As in human rated PROM, this may be subject to bias whereby an owner wishes to report either improvement or lack of change in certain circumstances. Alternatively completion of a PROM (by the responsible human for the horse) may be limited due to either lack of knowledge or simply poor understanding of the horses' behavioural changes and clinical signs presenting as a result of the musculoskeletal condition. To date, the use of PROMs reported by a proxy for the horse has not yet been reported in either the scientific literature or the lay press.

Another approach to assessing change following treatment is to use outcome measures that do not rely on a third party completing them, but instead are a direct outcome measure – also known as objective measures (OBJM) (Goff, 2016). Measures of baseline for a variety of variables such as range of motion, muscle strength or fitness can recorded by the physiotherapist and these scores can be monitored for change through the intervention phase (treatment period) to assess progress and report on the final outcome of treatment. Comparison of pre- and post-treatment data can be used to determine the effectiveness of a given treatment therefore the usefulness of the chosen intervention (treatment) and potentially increasing the evidence-base for the treatment/intervention applied.

According to a recent survey of equine physiotherapists (Tabor and Williams, 2018) over 80% reported to use OBJM, however the measures used were mainly subjective, such as visual assessment of lameness, palpation and muscle symmetry. Respondents identified the lack of validated measures available to clinicians as a primary reason for not using OBJM. There was also a perception that measures reported in the veterinary literature are difficult to use and time consuming. For example, in the laboratory setting the thorough study of forelimb and hindlimb kinematics and kinetics (Clayton and Back, 2013a; Clayton and Back, 2013b) has increased understanding of equine locomotion using gold standard, objective methods of data collection, such as three-dimensional analysis with digital optical motion capture systems and force plates to capture ground reaction forces (Clayton and Schamhardt, 2013). However in reality the equipment required to carry out these assessments is expensive, difficult to move around, and requires time to calibrate and to process data, so are not routinely used in clinical physiotherapy practice.

The aim of this paper is to review OBJM that could be used in clinical practice, rather than in a laboratory or research setting, by physiotherapists whilst treating horses.

In addition to referring to a core Animal Physiotherapy textbook (Goff, 2016) a literature search was performed in Science Direct, Wiley Online databases and Google Scholar using the following keywords in various combinations: 'equine', 'horse', 'physiotherapy', 'rehabilitation', 'measure', 'objective', 'outcome' within date range 1990 – 2019. The titles and abstracts of the retrieved studies and those not relevant were discarded with the reference lists of the selected articles searched for additional references. Articles found were categorised into sections relating to measurement area and reviewed: pain assessment in horses; gait assessment; spinal posture and range of movement; goniometry; palpation and muscle size.

Pain assessment in horses

The recognition and management of pain is crucial to the welfare of horses (Dalla Costa *et al.*, 2014) however there is very little published research into scales to assess pain in horses (Gleerup *et al.*, 2015) although it is known that the ability of the observer to recognize pain influences the efficacy of subjective pain scales (Bussieres *et al.*, 2008). There are multiple measures used to assess musculoskeletal pain in humans, many based on verbal reports to document quantity (intensity) and quality as well as the pain experience, and how these effect function, sleep and mood for example (Hawker *et al*., 2011). However, pain assessment in animals is limited due to lack of self-reporting and reliance on observation of behaviours reportedly associated with pain (Dyson *et al.*, 2018). Detection of pain by changes in physiological markers, behaviour (Bussieres *et al.*, 2008) and in facial expression have been suggested as proxy measures for pain in animals (Dalla Costa *et al.*, 2014; Gleerup *et al.*, 2015). The Horse Grimace Scale (HGS) has been developed and validated as a practical tool to assess post-operative pain (Dalla Costa *et al.*, 2014). The HGS uses observation of horse behaviour and facial expression, through a three point scoring system of scoring six Facial Action Units (stiffly backwards ears, orbital tightening, tension above the eye area, prominent strained chewing muscles, mouth strained and pronounced chin and strained nostrils). Based on high inter observer reliability and correlation with composite pain scores when tested in horses following castration, the authors suggest that the HGS may be of use in other clinical scenarios. A second research group quantified an ethogram based on the presence or absence of certain behaviours and facial expressions in horses prior to and after application of a noxious stimuli (Gleerup *et al.*, 2015). As per Della Costa *et al*. (2014), Gleerup *et al*. (2015) indicated that facial expressions (change in ear position and appearance of eyes, nostrils and lips) were exhibited during periods of pain, and named this the Equine Pain Face (EPF). To further validate the HGS as a specific tool to assess pain Dalla Costa *et al*. (2017) attempted to investigate if emotional states effect the score, and suggested that positive and negative emotional states did not differ from control HGS. Both studies of facial expression as well as previously validated studies of composite pain score (Bussieres *et al.*, 2008; Dalla Costa *et al.*, 2014; Gleerup *et al.*, 2015) assess behaviour in response to acute pain. Change in behaviour for chronic pain has yet to be fully investigated, so the HGS and EPC may not be reliable indicators of this type of pain, so caution must be applied when attempting to assess chronic pain with these scoring systems.

The HGS and EPF are used in assessments of the unridden horse, however most horses are also expected to perform under saddle therefore ethograms for assessing pain in ridden horses have been developed (Dyson *et al.* 2017; Dyson *et al.* 2018; Mullard *et al.*, 2017). Facial expressions in ridden horses (FEReq) were assessed and found repeatable when categorising horses as lame or not lame from photographs (Mullard *et al.*, 2017). In a larger scale study (Dyson *et al.* 2017) 519 photographs of ridden horses were analysed and the FEQeq score for lame horses was significantly higher than those for non-lame horses. In a small sub-group of horses that had received diagnostic analgesia to abolish pain significant differences in FEReq were identified before and after administration of medication. The authors did highlight limitations of assessment of pain from facial expression and have gone on to assess an ethogram that included the FEReq and whole-horse behaviours (Dyson *et al.*, 2018). Observers using this revised scoring system recorded significant difference in mean occurrence of behaviours in non-lame horses when compared to lame horses. It was established from this that the occurrence of eight of more markers, from a list of 24 behavioural descriptors suggests musculoskeletal pain. There is a clear need for objective pain assessment in clinical cases due to its impact on equine welfare (van Loon and van Dierendonck, 2019), consequently a combination of whole-horse behaviours and facial expression assessment could be utilised within physiotherapy assessment of pain in horses.

Gait Assessment

Evaluation of a horse's gait forms part of the systematic approach to the physiotherapy assessment procedure (Goff, 2016), however, it is the role of the veterinarian to establish whether there is an underlying pathological condition or not (i.e. provide diagnosis) as stated in the 2015 Exemptions Order of the Veterinary Act (1966) in the UK. If an irregularity or asymmetry is present it may or may not be considered a subclinical sign of lameness (Bragança *et al.*, 2018). There is considerable variation in scoring lameness between veterinarians (Fuller *et al.*, 2006; Keegan *et al.*, 2010) reducing the reliability of both inter-tester and test-retest measures by observation only. No published data on the ability of physiotherapists to assess gait exists.

A physiotherapist conducting a gait assessment may focus on assessing gait with a view to assess function of the neuromusculoskeletal system in addition to observing for lameness. Optimal movement is achieved through correct timing and co-ordination of muscle activity, as well as proprioception and balance. The ability for the musculature to control the limb movements based on a trunk that is dynamically stable is also required (Pfau *et al.*, 2017). Inertial Motion Unit (IMU) technology has been used to assess the limb and spinal motion (Bragança *et al.*, 2018) and measure the effects of a four week period of training period (Pfau *et al.*, 2017) however, as yet, no studies have used IMUs to objectively measure the effect of a physiotherapy intervention. Equine spinal motion has also been assessed in unridden horses with and without lameness, on straight lines and on circles (Greve *et al.*, 2015a; Greve *et al.*, 2015b). In addition at present there is debate within the veterinary community regarding what constitutes clinical lameness, potentially caused by pathology and what may be a non-limiting gait asymmetry (Van Weeren *et al.*, 2017). Although asymmetry can be measured, this information not conclusive until the relationship between performance, pain and the threshold for abnormal asymmetry is determined. In addition, whilst the use of IMUs contributes to the understanding of normal and abnormal kinematics, the set up and use of IMUs in daily clinical practice is yet to be commonplace.

Spinal Posture and Range of Movement

Spinal range of motion is often evaluated in equine musculoskeletal assessments. The cervical spine range of movement can be observed using a food bait to encourage the horse to move their head around to one side of the body, then to the other, to assess range of lateral flexion (Clayton *et al.* 2012) and forward to the chest or between the front legs (Clayton *et al.*, 2010), to assess cervical and thoracolumbar flexion. Manually induced reflexes to stimulate muscle contraction to create spinal motion in the thoracolumbar and lumbosacral regions are also used (Goff, 2016; Licka and Peham, 1998). Spinal motion assessed by both baited and reflex induced mobilisations are assessed subjectively in terms of range and quality of movement (Tabor and Williams, 2018). Recording movement via video footage however does allow for post-assessment objective analysis of posture (Tabor *et al.*, 2019; Taylor *et al.*, 2019) and range of movement (Taylor *et al.*, 2019), although only subjective rating of posture is reported to occur in practice (Tabor and Williams, 2018). Lesimple et al. (2012) found that there is a correlation between pain and posture during standing or during ridden exercise which is based on cervical spine position in horses that have a diagnosis of back pain in the thoracolumbar region. Achieving standardisation of body position is critical for comparing pre- and post-treatment/intervention measurements. In the horse, the standing position is considered to be repeatable when the horse is stood ‘square’ (lay terminology) and the plantar aspect of each metatarsus perpendicular to the ground, aligned with tuber ischii (Routh *et al*., 2017). The use of reliable and repeatable methodologies are needed to be able to validate measurements techniques (Heale and Twycross, 2015).

Goniometry

Whilst kinematic analysis can provide data on joint range of motion during gait (Clayton and Back, 2013a; Clayton and Back, 2013b), in clinical practice goniometry can be used to objectively assess joint motion, allowing evaluation of treatment intervention and outcome. A goniometer is a simple and inexpensive device commonly used in physical therapy and in horses (Adair *et al.*, 2016; Alrtib *et al.*, 2015; Liljebrink and Bergh, 2010) and has been validated against 'gold-standard' radiography. It has been shown to have high intra-tester reliability and low (Liljebrink and Bergh, 2010) or high average inter-tester reliability (Adair *et al.*, 2016), potentially due to variation in identifying the anatomical landmarks used and therefore the positioning of the goniometer between each assessor. Consistency in standing position (Alrtib *et al.*, 2015), similar to the requirement when assessing posture (Routh *et al.*, 2017; Tabor *et al*, 2019), use of an assistant and whether the horse is standing or anaesthetised in lateral recumbency (Liljebrink and Bergh, 2010) should be taken into account if repeated measures are to be reliable. To date, the reliability of goniometry has not been tested in a longitudinal study in horses. Therefore in clinical practice, to ensure confidence in repeated measures it is recommended that the same observer measures the joint angle with a goniometer on repeated occasions.

Range of motion of the cervical spine (distance of the horse's nose to shoulder) has also been proposed as a useful OBJM (Goff, 2016), however neither the reliability nor validity of this method have been tested in the horse.

Palpation

Clinical evaluation of musculoskeletal pain has traditionally included assessment by palpation, however its subjectivity limits its strength as a clinical or research outcome score (Varcoe-Cocks *et al.*, 2006). A pressure algometer (PA) (a handheld device), has been used to attempt to objectively measure pain response in horses during palpation (De Heus *et al.*, 2010; Haussler and Erb, 2006a; Haussler and Erb, 2006b; Menke *et al.*, 2016; Varcoe-cocks *et al.*, 2006). A PA uses a calibrated pressure gauge with an attached plunger that is pressed against the body (Figure 1). To assess repeatability, Haussler and Erb (2006a) conducted a number of experiments to assess the PAs value in differentiating the mechanical nociceptive threshold (MNT) in areas of known pain versus pain-free regions. The MNT refers to the specific point at which a physiological or behavioural response is noted, during the application of a quantifiable stimulus to a certain area of the body (Love *et al*., 2011). During the application of a PA, this threshold can be documented by recording the force (kg or N) being applied at this point. The MNT were higher over the spinous processes in the thoracolumbar region compared to over the temporomandibular joint for instance (Haussler *et al., 2006a)*. In this study 62 sites were tested three times each to establish repeatability, in 36 horses, with sequential increases in MNT in 24% of subjects showing adaptation to the pressure being applied, whilst 8% became more sensitised to the pressure. However the median range was 1kg/cm^2 which the authors note as their suggested measurement error, requiring a change of +/- 1kg.cm^2 to be used to assess for change in response to palpation. A further test of PA repeatability, in 12 thoroughbred racehorses by Varcoe-cocks *et al*. (2006) found that the PA scores, as well as being repeatable in four thoracolumbar and pelvis points, correlated with subjective scores of muscle palpation. PA appears to provide an objective repeatable clinical measure of MNTs, and therefore could be used to assess the therapeutic effectiveness of an intervention /physiotherapy treatment.

[Figure 1]

Multiple palpation scoring systems are used in human physiotherapy (Hawker *at al.*, 2011) to help the clinician understand pain levels, but they are subjective scales based on the verbal feedback given by the human patient. In the equine field, self-reporting is not possible therefore palpation scoring scales have been established (De Heus *et al.*, 2010; Varcoe-cocks *et al.*, 2006) that rely on scoring by a third party, usually the owner / keeper or rider (Table 1). These scoring systems can be used to score pain, tissue texture and behaviour responses and range from detailed systems which are less open to subjective bias to more basic systems such as the scale-based approach (normal, mild, medium) used by Jepsen *et al.* (2006) to record mechanosensitivity on palpation. In a recent study excellent inter-rater reliability was found between three qualified veterinary physiotherapists when manually assessing epaxial soft tissue using a palpation score and agreement was greater for manual palpation than a PA or an electronic force sensor (Merrifield-Jones *et al.*, 2019). In clinical practice detailed scales tend not to be utilised (Tabor and Williams, 2018) and worringly, use of subjective or no scales, could result in significant subjective interpretation and variability between clinicians.

Table 1: Example of palpation scoring scale, modified from Varcoe-Cocks *et al.* (2006) and the Modified Ashworth Scale (Ravara *et al.* 2015).

Score	Description
0	Soft, low tone
1	Normal
2	Increased muscle tone but not painful
3	Increased muscle tone and/or painful (slight associated spasm on palpation, no associated movement
4	Painful (associated spasm on palpation with associated local movement, i.e. pelvic tilt, extension response),

5	Very painful (spasm plus behavioural response to palpation, i.e. ears flat back, kicking).

Muscle size

A fundamental component of physiotherapy includes rehabilitation programmes that prescribe exercise for therapeutic purposes. Developing muscle strength (skeletal muscle hypertrophy) is one adaptation often desired within rehabilitation (Schoenfeld *et al.*, 2016). An example in this context would be exercises prescribed to address muscle atrophy of the thoracic paraspinal muscles related to back pain (muscle soreness) caused by saddles (Von Peinen *et al.*, 2010).

Cross sectional area (CSA), measured by ultrasonography has been used to record muscle size change (de Oliveira *et al.*, 2015; Stubbs *et al.*, 2015) in the multifidus muscles in the thoracolumbar spine plus thickness of the longissimus dorsi muscle has also been shown to be repeatable (Abe *et al.*, 2012). However access to the equipment needed for this measurement purpose, plus the requirement in horses for removal of hair which would otherwise trap air and impact imaging, is likely to restrict the use of ultrasonography to provide outcome measures in clinical practice.

Greve and Dyson (2014) have reported the use of a flexible curve ruler (FCR) to provide data on the shape and symmetry of the thoracic spinal profile finding a positive association between saddle slip and horses with a wider back shape at the 13th thoracic vertebrae compared with that at the 18th. In a subsequent study the FCR was used to measure longitudinal back dimension changes at two month intervals over one year (Greve and Dyson, 2015). Changes in shape and symmetry were related to factors associated with the horse, the saddle and rider. Therefore the FCR could be reliably used to assess for paraspinal muscle hypertrophy (or atrophy) as a result of a physiotherapy intervention. FCR of the profile at the 16th thoracic vertebral level has also been tested against CSA of *multifidus* however there appears to be no relationship between the size of this deeper stability muscle and the transverse profile (Tabor, 2015), suggesting the FCR is useful for a gross record of a region but not specific to individual muscle change.

Current use of objective measures in equine physiotherapy

There is evidence to support the reliability of individual OBJM, however inter-rater reliability is not a high as intra-rater reliability indicating that the use of tools and techniques to collect objective measurement could be used by individual practitioners confidently but with caution for multiple users. Despite this, even the use of these tools is reported to be limited by individual equine physiotherapists and to aid evaluation of interventions/physiotherapy treatments practitioners should select the most appropriate and reliable tool for the assessment requirement (Table 2).

Table 2: Summary of objective measurement tools evaluated for use in equine musculoskeletal assessment

Measure	Tool and purpose	Pros (✓)/ Cons (X)	Supporting Evidence
Range of Motion	Tape measure: Cervical spine lateral flexion – nose to landmark on trunk	✓Simple ✓Inexpensive X Reliability not tested	Clayton et al. (2010); Clayton et al. (2012); Goff (2016)
	Goniometry: Limb joint flexion and extension	✓Simple ✓Inexpensive X Peripheral joints only X low inter-rater reliability	Liljebrink and Bergh, 2010; Alrtib *et al.*, 2015; Adair *et al.*, 2016;
Posture	Photographs: Static spinal posture	✓Simple ✓Inexpensive X low inter-rater reliability X Computer software required	Lesimple *et al.* (2012); Tabor and Williams (2018)

	Video: Spinal posture from individual frames	✓Inexpensive X Inter-reliability not tested X Computer software required	Taylor *et al.* (2019)
Palpation	Palpation score: Pain (behavioural) response / muscle tone / spasm	✓Simple ✓Inexpensive ✓Excellent inter-rater reliability X Categorical scoring	Varcoe-cocks *et al.* (2006); De Heus *et al.* (2010); Merrifield-Jones *et al.* (2019)
	Pressure Algometry: Mechanical nociceptive threshold	✓Simple ✓Inexpensive X Inconsistent inter-rater reliability reported	Varcoe-cocks *et al.* (2006); Haussler and Erb (2006a); Haussler and Erb, (2006b); Menke *et al.*, 2016;
Muscle size	Flexicurve Ruler: Transverse profile of thoracolumbar spinal region	✓Simple ✓Inexpensive X Gross bulk measurement not individual muscles	Greve and Dyson (2014 & 2015)
	Ultrasound Scan: Muscle cross sectional area	✓Reliable ✓Measurement of individual muscles X Expensive equipment X Specialist training required	Abe *et al.* (2012); de Oliveira *et al.* (2015); Stubbs *et al.* (2015)

Future use of objective measures in equine physiotherapy

Within a physiotherapy assessment there is a requirement to use OBJMs and whilst factors such as muscle strength cannot be tested, in future the advances of technologies may allow the use of proxy measures in the clinical situation. Adopting proven practice from musculoskeletal assessment and physiotherapy management within human medicine is recommended for equine welfare and for professional practice. This would improve the support for certain treatments or rehabilitation interventions, for instance manual therapies, electrotherapies or exercise programmes. Studies investigating the efficacy of animal rehabilitation / physiotherapy inventions currently being used should examine and scrutinize the methodologies and the appropriateness of outcome measures used. For the profession to continue to work within the construct of increased requirement for evidence based practice, clinicians need to adopt a more widespread use of truly OBJMs. Use of reliable and valid measurements will strengthen the evidence base for the use of physiotherapy and rehabilitation in practice.

Conclusion

Validated outcome measures are needed to support clinical reasoning in selection of physiotherapy approaches to treated horses and to provide evidence of effectiveness. Whilst there are validated tools available at present (e.g. goniometry and palpation scores), these are not in consistent use in clinical practice. The challenges of a non-self-reporting patient should be taken seriously and the combined use of pain responses, behavioural changes and objective measures collected during assessment could be considered useful in practice once further validation of these has been conducted. Further development of existing measures in conjunction with validation studies of outcome scoring systems could enhance clinical equine physiotherapy practice.

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