Title:

Assessment of variation in movement symmetry measures in horses between trials, days and weeks based on inertial measurement units

Summary:

Implications This study provides guidelines for evaluating changes in movement symmetry, such as before and after diagnostic analgesia, or when evaluating the long-term effect of treatment or rehabilitation regimes in horses with orthopaedic disease.

Introduction Inertial Measurement Units (IMUs) are increasingly utilised as a tool for objective gait analysis in horses allowing unobtrusive instrumentation and quantification of clinically relevant gait parameters such as movement symmetry that are crucial for assessment of lameness. IMU systems have been shown to agree well with gold standard motion capture (Pfau *et al.*, 2005) and force platform measurements (Keegan *et al.*, 2012). IMUs agree moderately well with subjective assessment by Veterinary surgeons (Thomsen *et al.*, 2010). While repeatability of repeat assessments, conducted in short (5 minute) succession has been assessed and good agreement been reported (Keegan *et al.*, 2010), there is to date no data about biological variation of IMU derived symmetry measures days or weeks apart. This however is essential in order to establish reliable thresholds for monitoring the success of treatment or rehabilitation regimes. Hence, this study aimed at quantifying variation in kinematic symmetry parameters for serial measurements over time, attributable to intra-individual variation.

Material and methods IMUs were attached to head (poll), sacrum and left and right tuber coxae of six horses trotting on a motorized equine treadmill and vertical displacement was calculated during trot. Established movement symmetry measures were derived from these data over a five week period. These measures assess overall amount of asymmetry present (symmetry index; SI), differences in weight bearing between contralateral limbs (minimum difference; MinDiff) and differences in propulsion between contra-lateral limbs (maximum difference; MaxDiff) for front limbs (poll sensor) and hind limbs (sacrum sensor). Between-trial (differences between multiple measurements on a given day), between-day and between-week limits of agreement (LoA) were calculated following the method described by Bland and Altman (1986) as mean difference +/- 2 standard deviations of the difference.

Results LoAs were narrower for the sacrum compared to the poll. LoA for the sacrum SI increased from [-0.095 to +0.115] between trials to [-0.156 to +0.145] between days and to [-0.256 to +0.268] between subsequent weeks. Poll SI also increased from [-0.169 to +0.21] (between-trial) to [-0.331 to 0.353] (between days) to [-0.450 to 0.458] between weeks. Sacral MinDiff (MaxDiff) increased from [-4.9 to +4.5] ([-2.8 to +5.1]) mm (trials) to [-7 to +7.9] ([-5.1 to +5.1]) mm (days) and [-9.1 to +9.5] ([-16.6 to +17.7]) mm (weeks). Poll MinDiff (MaxDiff) showed increase from [-10.2 to +8.6] ([-10.9 to +12.3]) mm, [-12.7 to +13.3] ([-13.1 to 13.8]) mm to [-31.5 to 34.7] ([-17.3 to 21.2]) mm.

Conclusion In this study we have quantified variation in head and pelvic movement symmetry measures from IMUs by establishing limits of agreement on a trial-to-trial, day-to-day and week-to-week basis. This has demonstrated an increase in variation in particular on a week-to-week basis. Trial-to-trial and day-to-day LoA generally show values smaller or at least similar to our currently established thresholds for discriminating between sound and mildly lame horses and hence confirm these. In particular trial-to-trial LoA values should be considered when evaluating the effect of diagnostic analgesia comparing movement symmetry values before and after a nerve or joint block and day-to-day LoA values when investigating the effect of treatment or rehabilitation regimes.

Acknowledgements

References

Bland, J,M. and Altman, D.G. 1986. Lancet, i, 307-310.

Keegan, K.G., Kramer, J., Yonezawa, Y., Maki, H., Pai, P.F., Dent, E.V., Kellerman, T.E., Wilson, D.A. and Reed, S.K. 2011. American Journal of Veterinary Research. 72, 1156-1163.

Keegan, K.G., MacAllister, C.G., Wilson, D.A., Gedon, C.A., Kramer, J., Yonezawa, Y., Maki, H. and Pai, P.F. 2012. American Journal of Veterinary Research. 73, 368-374.

Pfau, T, Witte, T.H. and Wilson, A.M. 2005. Journal of Experimental Biology. 209, 3742-3757

Thomsen, M.H., Persson, A.B., Jensen, A.T., Sørensen, H. and Andersen, P.H. 2010. Equine Veterinary Journal Supplement 38, 510-515.