animals

Article

In Vivo Validation of a Metacarpophalangeal Joint Orthotic Using Wearable Inertial Sensors in Horses

Eleonora Pagliara [1,†], Federica Cantatore [2,*,†], Livio Penazzi [1], Barbara Riccio [1] and Andrea Bertuglia [1]

[1] Department of Veterinary Science, University of Turin, 10095 Grugliasco, Italy; pagliara.eleonora@gmail.com (E.P.); livio.penazzi@unito.it (L.P.); barbararicciovet@gmail.com (B.R.); andrea.bertuglia@unito.it (A.B.)
[2] Pool House Equine Hospital, IVC Evidensia, Rykneld Street, Fradley, Staffordshire WS13 8RD, UK
* Correspondence: fedecantatore10@gmail.com
† These authors contributed equally to this work.

Simple Summary

The metacarpophalangeal joint, or fetlock, plays a critical role in equine locomotion, flexing and extending with each stride. The surrounding tendons and ligament act like springs, absorbing and releasing energy and providing joint stability during motion. Injuries such as tendinitis and desmitis are common in performance horses and require complete healing to restore full functionality. While controlled exercise is fundamental to treatment, adjunctive support may be beneficial in managing severe soft tissue injuries. This study evaluated a novel fetlock orthotic device designed to limit excessive joint movement on the sagittal plane and soft tissue stretching during loading. Twelve healthy horses were assessed during walking and trotting, both without the device and with the orthotic applied at two different settings. The joint motion was quantified using sensor-based measurements. The orthotic significantly reduced the fetlock joint motion, particularly at the highest support level. These findings suggest that the orthotic device may stabilize the fetlock and serve as a supportive tool during rehabilitation following distal limb injuries in horses.

Abstract

Orthotics are often used to support the metacarpophalangeal joint (MCPj) in horses recovering from soft tissue injury; however, their effect on the MCPj biomechanics remain largely underexplored. The MCPj moves primarily in the sagittal plane, flexing during the swing phase and extending during the stance phase. The suspensory ligament and flexor tendons act as biological springs resisting MCPj extension. Injuries to these structures are common and, although early mobilization promotes their healing, controlled loading may be beneficial during rehabilitation. This study aims to evaluate the efficacy of a semirigid orthotic in limiting the MCPj extension and the MCPj range of motion, and its influence on the MCPj kinematics. Twelve healthy horses were equipped with portable inertial sensors on the distal limb. The MCPj extension and the MCPj range of motion were assessed during walking and trotting without the orthotic (S0) and with the orthotic using two different support settings (S1 and S4). Data were evaluated for normality and homoscedasticity. A Student *t*-test was used to compare the MCPj angle pattern of the two forelimbs of each horse at the baseline. Data were analysed using one-way ANOVA to compare the mean values across conditions, followed by paired *t*-tests for post-hoc comparison (significance set at $p < 0.05$). The results showed significant reductions in both the MCPj extension and the MCPj range of motion, with the greatest restriction occurring at the highest support setting. These results suggest that the semirigid orthotic limits the MCPj movement in the sagittal plane and consequently the load on the suspensory ligament and flexor tendons.

Academic Editors: David Argüelles and Ana Velloso Alvarez

Received: 18 May 2025
Revised: 29 June 2025
Accepted: 30 June 2025
Published: 4 July 2025

Citation: Pagliara, E.; Cantatore, F.; Penazzi, L.; Riccio, B.; Bertuglia, A. In Vivo Validation of a Metacarpophalangeal Joint Orthotic Using Wearable Inertial Sensors in Horses. *Animals* **2025**, *15*, 1965. https://doi.org/10.3390/ani15131965

Therefore, this orthotic device is an effective tool during rehabilitation for forelimb tendon and ligament injuries.

Keywords: horse; metacarpophalangeal joint; orthotic; inertial sensors; rehabilitation

1. Introduction

The equine superficial digital flexor tendon (SDFT) and suspensory ligament (SL) are designed to store elastic energy, enhancing the efficiency of locomotion [1]. The cyclic load on these structures is considered the leading cause of the high incidence of disorders in equine athletes [2–5]. In racing and athletic horses, injuries to the forelimb SL, its associated structures, and the SDFT are common and potentially career-limiting [2]. Tendon lesions tend to propagate significantly after the initial injury [6]. While the size of the lesion directly impacts the prognosis, limiting the damage to prevent the spread of the original lesion appears to be crucial [7]. The biomechanical load on the SDFT is maximal during the peak extension of the metacarpophalangeal joint (MCPj) which corresponds to the midstance and its maximal palmar moment [8–10]. Therefore, the joint extension and the flexion as well should be ideally limited during the rehabilitation of the SDFT and SL lesions. After the initial acute inflammatory phase lasting 10–21 days [6], early mobilization stimulates intrinsic healing and collagen fiber alignment in tendon and ligament damage [11,12]. However, these structures have low tensile strength and benefit from external support for gradual loading [11–15].

The metacarpophalangeal joint (MCPj) is a hinge-like joint which allows movements primarily in the sagittal plane. These movements include flexion, during the swing phase of the stride and the extension, at the end of the swing, and during the stance phases of the stride [16]. The extension/flexion graph of the MCPj, which defines the kinematic curve of the movement in the sagittal plane, has a repeatable pattern across horses [17]. When walking, the stance phase extension is prolonged, showing a tendency toward two peaks separated by a slight reduction in extension. When trotting, however, there is a single cycle of extension. Both gaits present two distinct flexion peaks in the swing phase of the stride. The first flexion peak in the swing phase of the stride results from the elastic recoil of the palmar structures supporting the fetlock joint. The mechanical properties of the palmar structures of the MCPj, including the suspensory ligament (SL), sesamoidean ligaments, SDFT, and the deep digital flexor tendon (DDFT) play a crucial role withstanding the MCPj extension [18]. The extent of the MCPj extension during movement can be assessed in vivo using inertial sensors, providing a proxy measure of load distribution and strain modulation within the associated structures [19]. Wearable inertial sensor units (IMUs) are extremely versatile because they are not invasive and can be used in field conditions without the need for a standardized laboratory [20].

An orthosis is a medical device applied to the body with the purpose of providing the support, the alignment, the positioning, deformity prevention or correction, assistance to weakened musculature, or enhancement of functional capacity [21]. Orthotic devices—commonly referred to as orthoses—are increasingly employed in veterinary practice to support and protect injured limbs during rehabilitation [22].

In equine practice, orthotic devices are used to support and protect injured limbs during rehabilitation. Their primary goals are to limit joint excursion, redistribute load, and enhance compliance with controlled exercise. A MCPj orthotic (Equestride™, Marysborough House, Glanmire, Co., Cork, T45 VX26, Ireland) claims to resist the extension of the MCPj and the metatarsophalangeal joint, limiting strain on flexor tendons and the SL.