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Point-Counterpoint

Problems at the human–horse interface and prospects for smart textile solutions

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ABSTRACT

The significant potential for so-called "smart textiles" in the design of the next generation of devices that measure pressure, tension, moisture, and heat at the human–horse interface is discussed in this article. Research techniques from theoretical and experimental physics laboratories, combined with wireless technology, can be readily adapted to measure and store metrics for numerous variables in equine structure and function. Activities, such as breathing, the extension and flexion of joints, limb kinematics, and cardiac function, can be logged as indicators of physiological and behavioral conditioning (training). Such metrics may also, one day, support veterinary diagnostics but also play a role in safeguarding sport-horse welfare, especially in elite contexts where the horse may be pushed to its functional limits. As such, they are likely to emerge as an area of great interest to equitation and welfare scientists. It is important to note that smart textiles sense and react to exogenous stimuli via integrated sensors. So, beyond the equitation science laboratory, the emergence of polymers and smart materials may enhance the effectiveness of, or challenge us to completely rethink, traditional items of saddlery, thus improving equitation. The integration of smart textiles in all sorts of extant and emergent equipment for everyday equestrians could, in the future, lead to equipment that responds appropriately to the demands of equitation in its various forms. Rethinking equitation through physics and the use of smart textiles seems to have merit in that it is a novel means of both investigating and addressing problems that compromise the welfare and performance of horses. The purpose of this article is to envision the use of smart textiles in research, clinical, equestrian, and horse care contexts.

Introduction

The nascent discipline of equitation science offers some unique opportunities for scientists because it combines the study of 2 animals working together and brings both performance and welfare benefits (McGreevy et al., 2009). By demanding an evidence-based approach to horse handling and training methods, equitation science highlights the need for data that characterize the ways humans interact with horses on the ground and under saddle. This discipline promises to reveal the role of the rider's hands, legs, and seat in eliciting and reinforcing desirable responses (McGreevy, 2007). It is expected that research into the effects of pressure cues in ethical, effective horse training will demonstrate the importance of timing and consistency, the proposed hallmarks of effective trainers (McGreevy and Boakes, 2007). Aside from the duration and intensity of pressure cues, equitation science must quantify the role of the materials that separate the human from the ridden horse.

To date, most of the research in equine studies and equitation science has been within the domains of biology and veterinary science. Theoretical and experimental physics offer equitation science the advantage of formulating theories, taking measurements

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and developing equipment in completely novel ways. We know that human mental states (e.g., nervousness) are known to have measurable effects on horse heart rate (e.g., König von Borstel et al., 2008), and simple accelerometry has been used to expose motor asymmetry in unridden horses (Warren-Smith and McGreevy, 2010). There is significant potential for so-called "smart textiles" to contribute more fully to such findings as consituents of devices that measure pressure, tension, moisture, and heat at the human–horse interface. Smart textiles have been implemented in several ways to monitor the health of humans (Lymberis and Olsson, 2003; Pantelopoulos and Bourbakis, 2010; Cherenack and Van Pieterson, 2012). Integrating smart textiles with standard horse equipment will advance measurement-taking and scientific research without distressing the horse or causing it pain. Given that horses are often highly reactive to external stimuli (as suggested by McGreevy et al., 1995 and Visser et al., 2001, who report equine responses to adverse housing and management conditions and fear-eliciting stimuli), using smart textiles promises to deliver more reliable results than we have been able to report so far because the measurement equipment can be integrated into gear that is familiar to horses.

Pressure is a function of force applied to a given surface area and is ubiquitous in horse training. Force applied to a small area can result in very high pressure. Tack is designed to either disperse pressure (e.g., in the case of the saddle) or concentrate pressure (e.g., in the case of head restraint). It has been suggested that in tack designed to concentrate pressure, the smaller the interface with the horse, the more severe the device and the greater the need for excellent timing in pressure-release (McGreevy and McLean, 2010). The principles of either dispersion or concentration apply whenever tack is constructed from traditional materials, such as leather, nylon, metal, and rubber. Relentless, unintended, or random pressures through any interface intended to facilitate signaling to the horse are generally contraindicated because, it is proposed, they lead to habituation and, ultimately, either detraining or the need for more uncomfortable and possibly painful pressures (McGreevy, 2011).

Designing novel means of dispersing and applying pressure to the ridden horse could revolutionize working-horse comfort. The emergence of polymers and smart materials may enhance the effectiveness of traditional items of saddlery and is likely to become an area of great interest to equitation and welfare scientists. There are now materials that are sensitive to changes in pressure, have memory of shape, react to chemical changes, and alter conductivity. In the current article, after discussing the construction of the equipment, we explore its use in various equestrian disciplines.

Why smart systems and smart textiles?

The most common definition of smart systems describes intelligent materials and systems that can sense and respond to their surrounding environment in a predictable and useful manner (Schwarz, 2002). This definition of a smart system applies very well to a smart textile system (Schwarz et al., 2010). Depending on its behavior, a smart textile system can be classified into 3 categories (Tao, 2001):

- Textiles with a sensing function, referred to as passive smart textiles. Examples include stretch and pressure-sensing structures.
- Textiles with an actuating function, referred to as active smart textiles because they sense a stimulus from the environment and also react to it. Examples include color- and shape-change materials.
- Textiles with an adaptive function, referred to as very smart textiles because they take a step further in that they can adapt their behavior to circumstances.

In the third category, the signals generated by the textile sensors and/or actuators can be processed and stored using electronics and computer-aided measurement methods (Malaric, 2011). The textile sensors can be modelled using finite element methods (FEM) to solve the multiphysics problem of characterizing the relationships between a measured signal and an applied stimulus. FEM is a numerical method in which real-life problems with complex geometry and nonlinear physical relations can be solved by dividing the geometry into its component parts. The nonlinear physical relationships can then be solved for each element, and the overall solution is obtained by adding up all the partial solutions (Davies, 2011). A multiphysics approach takes into account all relevant physical relations when solving the FEM equations (Lethbridge, 2005). Generally, the simulations recorded from pilot studies further aid the design of sensors and their position in the textile structures to optimize the quality of the signal and the information obtained. An example of a typical FEM calculation is shown in Figure 1, in which the pressure from a bit on a tongue is analyzed.

The integration of intrinsic sensing functions into textile structures combined with electronics is an elegant way to measure the environment, and sensors integrated in human clothing and other types of textile products have considerable appeal for wearable interfaces because of their soft, pliable, and washable characteristics. The challenge of integrating biophysiological sensors into human clothing is of growing importance in the e-health services. Textile sensors have already been developed for a wide range of physiological monitoring needs—the most common are sensors for monitoring physiological parameters such as heart rate (Paradiso et al., 2005; Wiklund et al., 2007), muscle activity (Finn et al., 2007), and breathing patterns (Taccini et al., 2008).

So far, most of the human clothing innovations have used conductive and piezo-resistive textile structures. The integration of optical fibers, for example, to monitor breathing, is a more recent innovation (Grillet et al., 2008). However, there are also sensors for more sophisticated forms of touch measurement that use changes in the electronic properties of capacitive switches to define touch (Hoffmann et al., 2011). We argue that the potential for using smart textiles in equitation science has generally been overlooked. Equestrian coaches often emphasize the importance of feel (pointing out that riders rely on biofeedback in their application of pressure cues), but have no objective means of assessing it (McGreevy, 2007).

The time seems right for a multidisciplinary approach involving physics (theoretical and experimental), textile research, and

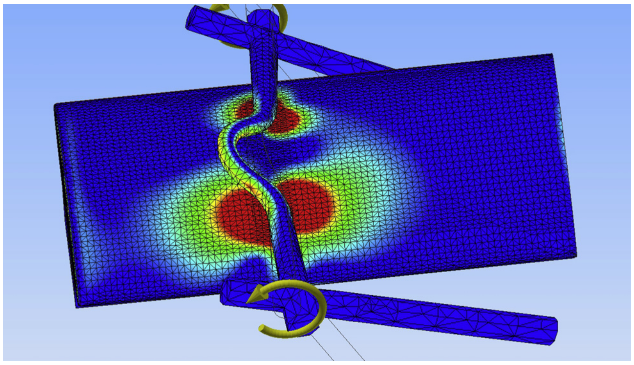

Figure 1. A finite element methods analysis of the pressure imposed by a bit.