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Original Research

A Pressure-Sensitive Glove for Standardization of the Force Applied During Distal Forelimb Flexion Tests in Horses

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ABSTRACT

The force applied by the surgeon, during a flexion test, has a strong influence on the outcome of the test. The objective of this study was to verify if a commercially available pressure-sensitive glove could be used to standardize the force applied in the equine distal forelimb flexion test. Three experienced veterinary surgeons and three final-year students performed bilateral distal forelimb flexion tests on cadaver limbs and on live horses with a pressure-sensitive glove. All participants were asked to apply a constant force for 60 seconds using the indicator on the glove display while a camera recorded the value on the glove display. The videos were reviewed and the percentage of time for which the correct force was applied was measured. No significant differences were found between the percentages of time of application of the standard force between experienced and non-experienced operators ($P = .802$). No statistical difference was found between experienced and inexperienced operator either in live horses ($P = .591$) or in the cadaver model ($P = .797$). In conclusion, the pressure-sensitive glove could become an essential and affordable tool for the equine practitioner, facilitating standardization of the test.
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1. Introduction

Lameness evaluations with flexion tests are a routine procedure for equine practitioners and are commonly used in both lame and sound horses [1–6]. Positive or also negative results in these evaluations may help the clinician to understand the origin and the severity of the lameness. Previous studies have investigated factors that may influence the outcome of flexion tests [1–6] and divided them into three categories: examiner-related factors, physiological horse-related factors, and pathologic horse-related factors [6]. Examiner-related factors (force and time) have a strong influence on the outcome of the test, and several studies [2,3,5] have shown low interexaminer repeatability of the applied force. All the author cited recommended strict standardization of the force applied on the horse's limbs and the time of application. For this purpose, various force-measuring devices have been developed [3,4]. These devices are not widely used in practice, possibly because they are not commercially available and self-manufacturing may not be possible for everybody.

The hypothesis of this study was that a commercially available pressure-sensitive glove, which was initially designed to measure the pressure applied by the fingers on a golf club, could be successfully used as a tool to standardize the force applied by the operator in the equine distal forelimb flexion test. The purpose of the study was to verify if a commercially available pressure-sensitive glove allows operators with different levels of experience to consistently apply a constant force for a standardized time during the distal limb flexion test in horses.

2. Materials and Methods

2.1. Instrumentation Description

The commercially available pressure-sensitive glove (SensoGlove, Senso Solutions GmbH, Aachen, Germany) is

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made of leather and contains one pressure sensor in each finger; each pressure sensor is made with a small balloon filled with air. This balloon when compressed send to a small computer placed on the dorsum of the glove the degree of compression of which it has been subjected which is then transformed by the software with a specific algorithm in a measure of pressure applied (Fig. 1). The computer has a small display that allows continuous monitoring of the pressure applied by each finger with instant visual and audio feedback. Once established the proper "grip" pressure, the glove will beeps at the precise point when the pressure violation is occurred. The pressure setting can be easily changed by means of dedicated buttons. If the glove becomes worn or if the operators use gloves of a different size, the computer can be removed and transferred to another glove with a simple move.

The SensoGlove is easily accessible to anyone and, at the time of writing, costs approximately $89 (80.68 €) for the complete glove and $22 (19.29 €) for the glove without the computer (excluding shipping cost), and it can be purchased easily trough the main Website of the manufacturer (www.sensoglove.com). The computer has a scale (inner scale provided by the manufacturer) (Fig. 1) ranging from 1 (low sensitivity) to 18 (high sensitivity) that allows the operator to increase or decrease the sensor sensitivity depending of the need. Decreasing the number reduces the sensitivity, thus increasing the maximal force that may be applied on the sensors and vice versa. A visual force scale (Fig. 1) allows monitoring of changes in the pressure, and an acoustic warning indicates that the maximal value has been exceeded. For the perfect application of the set force, the operator must remain in the middle of the visual scale (Fig. 1). To increase the registered value on the visual force scale, it is sufficient to apply pressure on one finger at a time because the device can differentiate on which finger is applied the main force or in which finger the grip is too tight or too soft. If the force is applied to more than one finger, the display shows the fingers on which the force is applied and the computer registers the maximal force exerted by all the fingers involved, reporting which finger is overcoming or not the set force.

Fig. 1. The display of the computer with the visual scale and the sensitivity number.

Because the leather of the glove was too thin to withstand continual contact with a horse hoof, we applied a more robust working glove onto the pressure-sensitive glove. This adjunct was proved by previous testing conducted by the author not to modify the sensitivity of the pressure-sensitive glove. Because the glove is designed to measure the pressure exerted by each finger on a golf club during the swing phase, it is not originally set to measure pressures as high as 100 N. For this reason, we asked the producer to modify the software of the glove by decreasing the sensitivity to the air pressure generated by the compression of the balloons. This way, while before end scale was achieved with a pressure of say approximately 10 N, after this modification, the glove can detect pressures up to 200 N before reaching end scale.

2.2. Calibration of the Glove

The glove was calibrated using a dynamometer (HCB200K100, Kern&Sohn, Balingen, Germany) connected to a handle. The pressure was increased until the value on the visual scale of the glove (left part of the display) was at the midscale point, which resulted in the audio warning. In accordance with the suggestions provided by Verschooten and Veerbeck [4], we have chosen a force of 100 N that corresponds to the midscale value on the glove display when sensitivity was set at 16 (sensitivity inner scale of the glove) (Fig. 1).

2.3. Study Population

Three inexperienced (fifth-year veterinary students), two males and one female mean age of 24.6 years, and three experienced (i.e., more than 3 years of experience in equine lameness evaluations) clinicians, two males and one female, mean age 35 years, participated in the study. Before starting the tests, each volunteer was asked to report the leading arm. They were then asked to perform the distal limb flexion test in a cadaver model and on live horses using the pressure-sensitive glove. For the cadaver model, a complete left and right limb distal was obtained from regularly slaughtered horses at a local abattoir. For the live horses, informed consent was obtained from the owners.

2.4. Performance of the Flexion Test

The flexion test of the distal limb was performed as described by Busschers and Van Weeren [6] and Keg et al [3] (Fig. 2); the examiner exerted a force on the dorsal surface of the hoof-wall with the glove, while maintaining the metacarpus in a vertical position. The upper arm of the examiner exerted a contrapressure on the distal radius of the horse [3,6]. After receiving brief training from an experienced clinician, the inexperienced participants carried out the flexion test under supervision. All the

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