Journal of Biomechanics 44 (2011) 1414–1416

Contents lists available at ScienceDirect

Journal of Biomechanics

journal homepage: www.elsevier.com/locate/jbiomech
www.JBiomech.com

Short communication

Effects of different temperatures, velocities and loads on the gliding resistance of flexor digitorum profundus tendons in a human cadaver model

Tamami Moriya, Takako Chikenji, Andrew R. Thoreson, Chunfeng Zhao, Kai-Nan An, Peter C. Amadio*

Biomechanics Laboratory, Division of Orthopedic Research, Department of Orthopedic Surgery, Mayo Clinic, 200 First Street SW, Rochester, MN 55905, United States

ARTICLE INFO

Article history:
Accepted 5 January 2011

Keywords:
Tendon
Friction
Load
Temperature
Velocity

ABSTRACT

The purpose of this study was to investigate the effects of temperature, velocity and load on the gliding resistance (GR) of flexor digitorum profundus (FDP) tendons in a human cadaver model. A total of 40 FDP tendons from the index through small digits of ten human cadavers were tested to assess the effect of temperature (4, 23 or 36°C), velocity (2, 4, 6, 8, 10 or 12 mm/s) and load (250, 500, 750, 1000, 1250 and 1500 g) on GR. The mean GR at 4 °C was significantly higher than the mean GR at 36 °C ($p<0.0066$). There was no significant difference in the mean GR of the tested velocities. The mean GR was proportional to load, with each successive load having significantly higher GR than the loads before it (all $p<0.001$). There was no significant difference in the mean GR by digit. In this in vitro model, we have demonstrated that tendon gliding resistance is proportional to load, independent of velocity and somewhat affected by temperature. We conclude that it is important to specify these conditions when reporting gliding resistance, especially load and temperature.

1. Introduction

Gliding resistance of tendon has been generally considered as an important parameter, which influences tendon function. There have been many manuscripts using the gliding resistance in a human cadaver model (Berschback et al., 2005; Coert et al., 1995; Moriya et al., 2010; Zhao et al., 2001a). All gliding resistances of the tendon–pulley interface in these studies were measured using the methods of Uchiyama et al. (1995), with the specimens in a saline bath at room temperature (i.e., 23 °C), the velocity of specimens set at 2 mm/s and the load on the flexor digitorum profundus (FDP) tendons as 4.9 N (i.e., a 500 g weight). However the effects of different temperatures, velocities and loads on the gliding resistance of FDP tendons in a human cadaver model are still unclear. The purpose of this study was to investigate the effects of different temperatures, velocities and loads on the gliding resistance of FDP tendons in a human cadaver model.

2. Material and methods

2.1. Specimen preparation

After the Institutional Review Board (IRB) approval, 4 right hands and 6 left hands of 10 fresh frozen human cadavers were obtained, including 2 males' and 8 females', with an average age of 80.4 years (range 64–91). A total of forty FDP tendons from these hands were used for this study. Each finger was disarticulated at the MCP joint level, preserving the flexor tendons at the level of wrist. The FDP tendons were accessed through a transverse incision in the flexor sheath, just distal to the A2 pulley. The FDP tendons were marked at the level of the distal end of the A2 pulley both at full passive extension and at full flexion, with a 4.9 N load (i.e., a 500 g weight) attached to the proximal FDP tendon to maintain tendon tension. The distance between these two marks represented the FDP tendon excursion during full finger motion. The A1 and A2 pulleys and FDS tendons were preserved during the experiment.

2.2. Measurement of gliding resistance

The gliding resistance between tendon and pulley was measured using the method of Uchiyama et al. (1995). Briefly, the proximal and middle phalanges, A2 pulley, flexor digitorum superficialis (FDS), parietal membrane of A2 pulley and visceral membrane of FDP were preserved, while removing the remaining tendon sheath, pulleys and the distal phalanx. A Kirschner wire was used to stabilize the proximal interphalangeal joint in the neutral position. Each specimen was mounted on the custom testing device with the palmar side upward (Fig. 1). To maintain tension in the FDS tendon, a 2 N load (100 g weight) was attached to its proximal end. The magnitude of this load was determined based on previous in vivo tendon research, to replicate the magnitude of load experienced by normal tendons in situ (Schuind et al., 1992). The measurement system consisted of one mechanical actuator with a linear potentiometer, two tensile load transducers and a mechanical pulley. The distal transducer was connected to a load as described below. The proximal load transducer was connected to the mechanical actuator.

Based on the experience of previous studies, a 50° arc of contact, 30° and 20° between the horizontal plane and the proximal and distal transducer cables, respectively, is sufficient to provide accurate measurement of gliding resistance (Uchiyama et al., 1997; Zhao et al., 2001b). During finger flexion and finger extension, the tendon was pulled proximally by the actuator against the load at a rate as below. Excursion was limited to the distance between the two FDP tendon markers, thus reproducing the tendon excursion from full finger flexion to full finger extension. The forces at the proximal and distal tendon ends and the tendon

* Corresponding author. Tel.: +1 507 538 1717; fax: +1 507 284 5392.
E-mail address: pamadio@mayo.edu (P.C. Amadio).

0021-9290/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jbiomech.2011.01.011