MODELING OF THE MUSCLE/TENDON EXCURSIONS IN AN INDEX FINGER USING THE COMERCIAL SOFTWARE ANYBODY

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INTRODUCTION

Biomechanical models of the hand and fingers are essential tools to explore the mechanical loading in the musculoskeletal system, which cannot be easily measured in vivo. There are multiple biomechanical models of the hand and fingers simulating different problems (e.g., Sancho-Bru et al., 2003; Brook et al., 1995). However, all these previous models are formulated analytically/numerically and are not suitable for bioengineers and scientists to deal with practical problems. The goal of our study was to develop a universal biomechanical model of the hand, which includes the factors in physiological conditions. Specifically, we develop a kinematical finger model on the platform of the commercial software Anybody (version 2.0, Anybody Technology, Aalborg, Denmark) that includes the real micro-CT-scans of the bony sections and realistic tendon/muscle attachments on the bones. The model predictions on muscle excursions in an index finger are compared with published experimental data.

METHODS

The index finger is modeled as a linkage system, based on the normative model proposed by An et al. (1979) (Fig. 1). The index finger consists of distal, middle, proximal, and metacarpal phalanges. The DIP (distal interphalangeal) and PIP (proximal interphalangeal) joints are modeled as hinges with one DOF about the z-axis; while the MCP (metacarpophalangeal) joint is modeled as a universal joint with two DOFs about the y- and z-axes. The dimensional scale of the normative finger model (An et al., 1979) is adopted into the current modeling. The attachment locations of the tendons are also defined according to the normative model. Seven muscles were included in the proposed model: Flexor profundus (FP), flexor sublimis (FS), extensor indicis (EI), extensor digitorum communis (EC), radial interosseous (RI), ulnar interosseous (UI), and lumbrical (LU). In order to better visualize the muscle/tendon attachment locations and to guide the muscle/tendon during the movements, the real bony section meshes were implemented into the proposed index finger model. These bony section meshes were obtained via micro-CT scanning of a cadaver right hand and included into the model. The predicted muscle/tendon excursions and moment arms were compared with the published experimental data (Fowler et al., 2001; An et al., 1983). Only the excursions of each individual muscle/tendon have been calculated directly in the study. The moment arm of the muscles/tendons corresponding to a particular joint is derived by differentiating the excursions with respect to that joint rotation (An et al., 1979).

RESULTS AND DISCUSSION

The variations of the muscle/tendon excursion and moment arm in response to the flexion/extension of the DIP and PIP joints as well as the flexion/extension and adduction/abduction of the MCP joint individually are calculated and compared with the experimental data. Typical results, the moment arms of the muscles/tendons corresponding to the PIP flexion, are shown in Fig. 2. In this test, there are six relevant muscles: EI, EC, UI, LU, FS, and FP. Since the moment arms of EI and EC muscles are identical, only the result for the EI muscle is shown. The model predictions agree well with the experimental measurements that the moment arms for the FS/FP muscles are negative, while those for the other three muscles (EI/UI/LU) are positive.

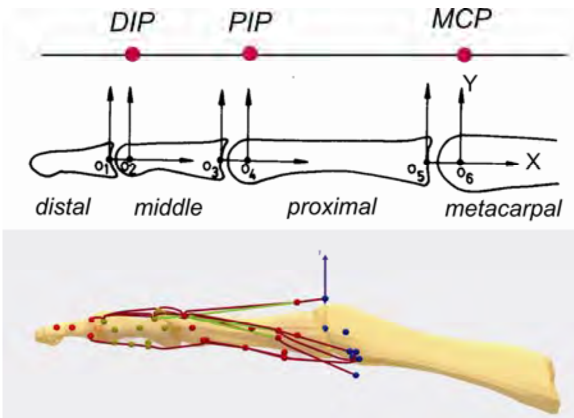

Figure 1: Schematic of the proposed finger model, which is based on the normative model (An et al., 1979). The DIP, PIP, and MCP joints are assumed to be located at O2, O4, and O6, respectively.

SUMMARY/CONCLUSIONS

In the present study, we proposed a universal model to simulate the muscle/tendon excursions and moment arms of the fingers on the platform of the commercial software AnyBody. One of the important features of the proposed model over the previous models is that the proposed approach can include the realistic bony geometries, which are associated with the muscle excursion and moment arms.

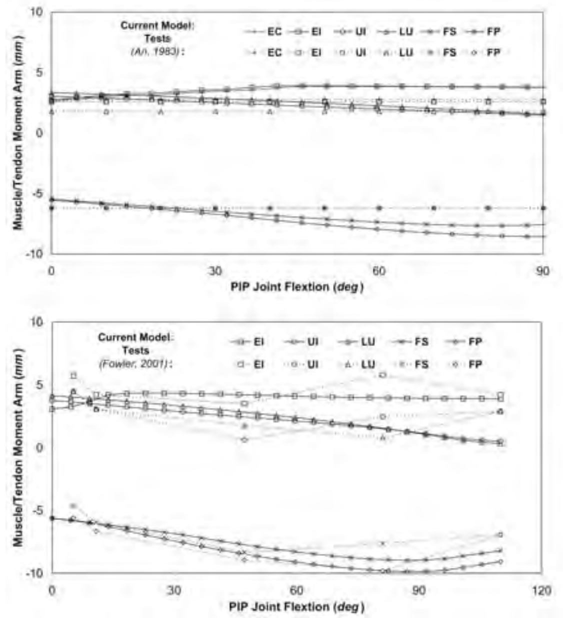

Figure 2: The predicted muscle/tendon moment arms as a function of the PIP joint flexion in comparison with the corresponding experimental data by An et al. (1983) and Fowler et al. (2001).

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Brook, N., Mizrahi, J., Shoham, M., Dayan, J. (1995). *Med Eng Phys* 17 (1):54–63.

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Sancho-Bru, J.L., Perez-Gonzalez, A., Vergara, M., Giurintano, D.J. (2003). *J Biomech Eng*, 125 (1):78–83.

DISCLAIMER

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the *National Institute for Occupational Safety and Health*.

4:00 **An algorithm for automated tracking of tendon excursion from ultrasound images**
Sabrina Lee, Gregory Lewis, Stephen Piazza
Corresponding Author: Stephen Piazza
The Pennsylvania State University

4:15 **Cruciate ligament force during the wall squat and one-leg squat**
Rafael F. Escamilla, Naiquan Zheng, Alan Hreljac, Rodney Imamura, Toran D. MacLeod, William B. Edwards, Glenn S. Fleisig, Kevin E. Wilk
Corresponding Author: Rafael Escamilla
California State University, Sacramento

Friday, August 24, 2007 — 9:45 - 11:00 AM

Podium 13: Locomotion Energetics
Memorial Auditorium

Chair: Young-Hui Chang

9:45 **Comparison of two methods of determining relative effort during sit-to-stand**
Dennis Anderson, Kathleen Bieryla, Michael Madigan
Corresponding Author: Kathleen Bieryla
Virginia Tech

10:00 **Independent effects of body weight and mass on the metabolic cost of running**
Alena Grabowski, Rodger Kram, Lennart Teunissen
Corresponding Author: Alena Grabowski
University of Colorado, Boulder

10:15 **Disintegrating the metabolic cost of human running: weight support, forward propulsion, and leg swing**
Rodger Kram, Erin Warddrip
Corresponding Author: Rodger Kram
University of Colorado - Boulder

10:30 **Mechanics and energetics of level walking with powered ankle exoskeletons**
Daniel Ferris, Gregory Sawicki
Corresponding Author: Gregory Sawicki
University of Michigan-Ann Arbor

10:45 **Center of mass velocity redirection predicts COM work in walking**
Peter Gabriel Adamczyk, Arthur D. Kuo
Corresponding Author: Peter Gabriel Adamczyk
University of Michigan

Friday, August 24, 2007 — 9:45 - 11:00 AM

Podium 14: Hand

Annenberg Auditorium

Chair: Zong-Ming Li

9:45 **Comparison of finger force enslaving and sharing between mvf and oscillatory finger force production tasks**
Qi Li, Marcio A. Oliveira, Jae Kun Shim
Corresponding Author: Qi Li
University of Maryland

10:00 **A data-driven Markov Chain Monte Carlo Metropolis-Hastings algorithm for a model of the human thumb**
Carlos Bustamante, Veronica Santos, Francisco Valero-Cuevas
Corresponding Author: Veronica Santos
Cornell University & The University of Southern California

10:15 **Modeling of the muscle/tendon excursions in an index finger using the commercial software AnyBody**
Kai-Nan An, Robert G Cutlip, Ren G Dong, John Z Wu
Corresponding Author: John Z Wu
National Institute for Occupational Safety and Health

10:30 **Variation in force and moment stabilizing synergies with different finger combinations: an uncontrolled manifold analysis**
Sohit Karol, Jae Kun Shim
Corresponding Author: Sohit Karol
University of Maryland, College Park

10:45 **Blind inference of tendon networks through minimal testing**
Hod Lipson, Anupam Saxena, Francisco Valero-Cuevas
Corresponding Author: Anupam Saxena
Cornell University & The University of Southern California

Friday, August 24, 2007 — 9:45 - 11:00 AM

Podium 15: Knee
Cubberley Auditorium

Chair: Heidi-Lynn Ploeg

9:45 **The effect of collagen fibres on permeability of articular cartilage**
Salvatore Federico, Walter Herzog
Corresponding Author: Salvatore Federico
The University of Calgary

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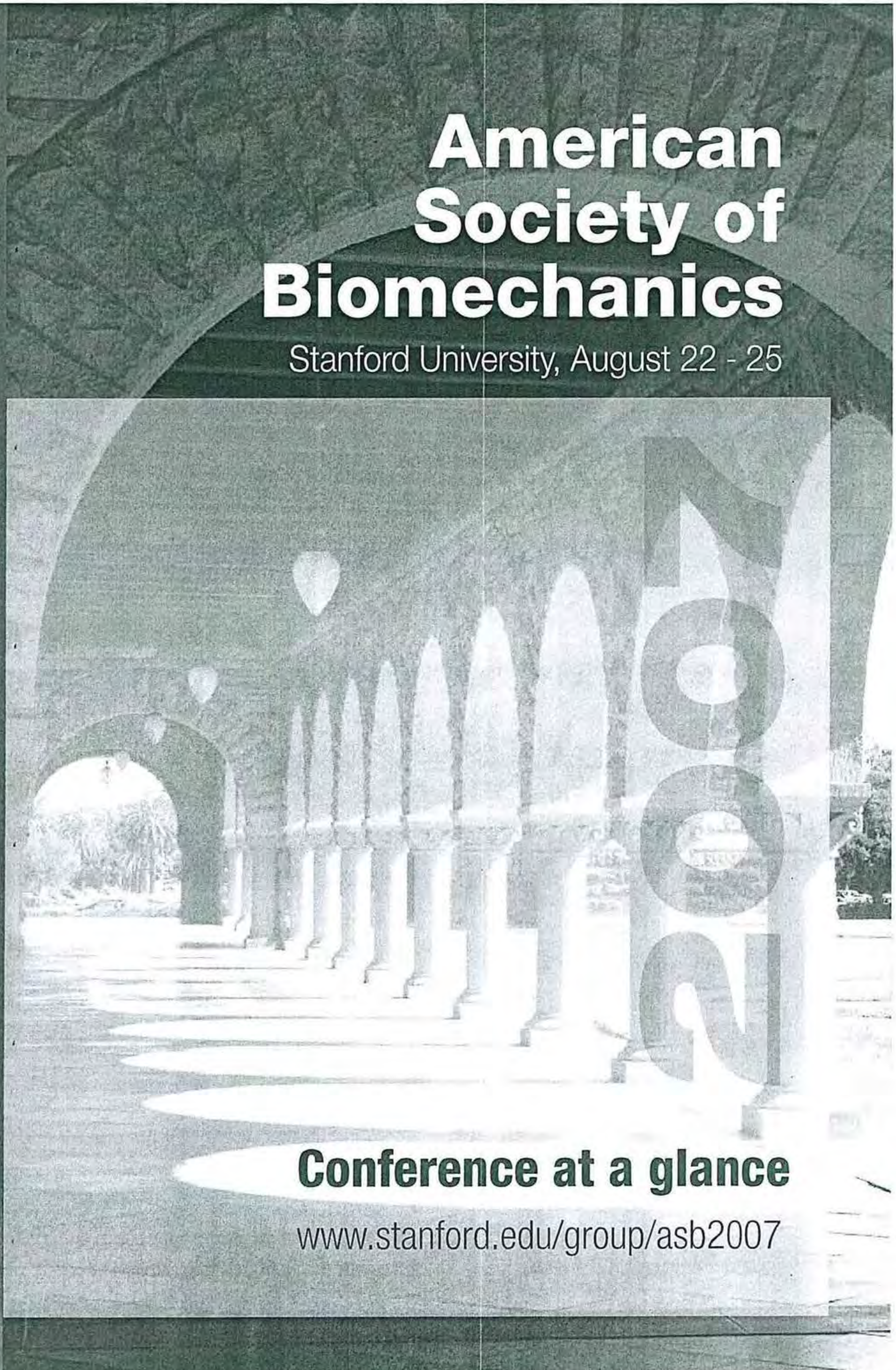
Stanford University, August 22 - 25



Conference at a glance

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