ELSEVIER

Journal of Biomechanics 41 (2008) 695–700

JOURNAL OF BIOMECHANICS

www.elsevier.com/locate/jbiomech
www.JBiomech.com

Technical note

The effect of direct measurement versus cadaver estimates of anthropometry in the calculation of joint moments during above-knee prosthetic gait in pediatrics

Evan J. Goldberg[a,*], Philip S. Requejo[b], Eileen G. Fowler[a]

[a]Department of Orthopaedic Surgery, University of California at Los Angeles, 1000 Veteran Avenue, 22-64 Rehabilitation Center, Los Angeles, CA 90095, USA
[b]Rancho Los Amigos National Rehabilitation Center, Downey, CA 90242, USA

Accepted 5 October 2007

Abstract

Joint reaction forces, moments and powers are important in interpreting gait mechanics and compensatory strategies used by patients walking with above-knee prostheses. Segmental anthropometrics, required to calculate joint moments, are often estimated using data from cadaver studies. However, these values may not be accurate for patients following amputation as prostheses are composed of non-biologic material. The purpose of this study was to compare joint moments using anthropometrics calculated from cadaver studies versus direct measurements of the residual limb and prosthesis for children with an above-knee amputation. Gait data were collected for four subjects with above-knee prostheses walking at preferred and fast speeds. Joint moments were computed using anthropometrics from cadaver studies and direct measurements for each subject. The difference between these two methods primarily affected the inertia couple ($I\alpha$ term) and the inertial effect due to gravity, which comprised a greater percentage of the total joint moment during swing as compared to stance. Peak hip and knee flexor and extensor moments during swing were significantly greater when calculated using cadaver data ($p<0.05$). These differences were greater while walking fast as compared to slow speeds. A significant difference was not found between these two methods for peak hip and knee moments during stance. A significant difference was found for peak ankle joint moments during stance, but the magnitude was not clinically important. These results support the use of direct measurements of anthropometry when examining above-knee prosthetic gait, particularly during swing.

Keywords: Above-knee prostheses; Anthropometrics; Kinetics; Gait

1. Introduction

Joint kinetics are important in the interpretation of gait mechanics and compensatory strategies used by patients walking with above-knee (AK) prostheses. Segment anthropometrics (i.e., mass, center of gravity (CG) and moment of inertia (MI)), needed to calculate joint reaction forces, moments and powers, are often estimated using regression equations from cadaver studies (Dempster et al., 1959; Clauser et al., 1969). While this is a reasonable approach for many patient populations, errors may be introduced when calculating anthropometrics for prostheses. Previous studies have reported limitations of anthropometrics based on cadaver data (Dempster et al., 1959; Clauser et al., 1969) for use in certain patient populations (Jensen, 1986).

Direct measurements of the residual limb and prosthesis have been used to calculate anthropometrics in several studies (Seroussi et al., 1996; Gitter et al., 1997; Fowler et al., 1999; van der Linden et al., 1999). Methods for directly calculating anthropometrics include knife-edge balancing to find the CG and pendulum tests to calculate the MI (Seroussi et al., 1996; Fowler et al., 1999; van der Linden et al., 1999). Negligible differences in joint moments calculated using cadaver data versus direct

*Corresponding author. Tel.: +1 310 825 5858; fax: +1 310 825 5290.
E-mail address: egoldberg@mednet.ucla.edu (E.J. Goldberg).

0021-9290/$ - see front matter
doi:10.1016/j.jbiomech.2007.10.002

Table 1
Subject age, height and weight

Subject	Age (yrs)	Height (m)	Mass (kg)
1	14.1	1.75	67.50
2	15.3	1.75	71.60
3	12.9	1.64	55.45
4	11.9	1.44	32.55

measurements approaches have been reported for below-knee prosthetic gait (Czerniecki et al., 1991). Similar anthropometric studies could not be found for AK prosthetic gait. The purpose of this study was to compare joint moments calculated using anthropometry (1) estimated using cadaver data and (2) calculated using direct measurements of the residual limb and prostheses during AK prosthetic gait.

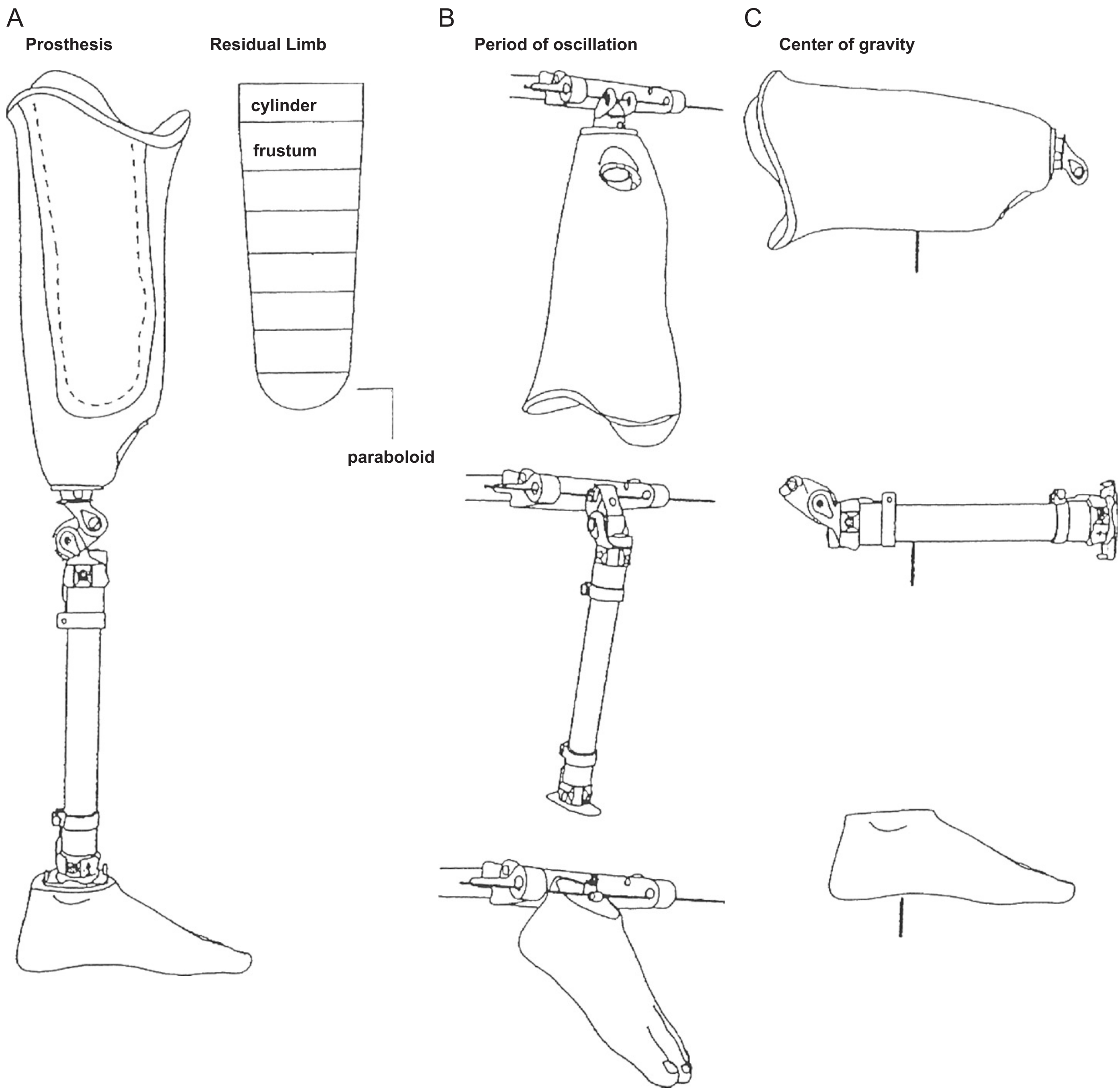

Fig. 1. Schematic diagram of methods used to determine prosthetic limb anthropometrics: (A) modeling of the residual limb, (B) measuring the period of oscillation and (C) measuring the center of gravity. The segments were oscillated to determine the period of oscillation (T). Moment of inertia (MI) of each prosthetic segment was calculated as $\mathrm{MI} = T^2\mathrm{mgd}/(2[\mathrm{pi}]^2)$. Corresponding residual limb and prosthetic components were combined to obtain one mass, center of mass and moment of inertia for each of the affected limb thigh, shank and foot segments.