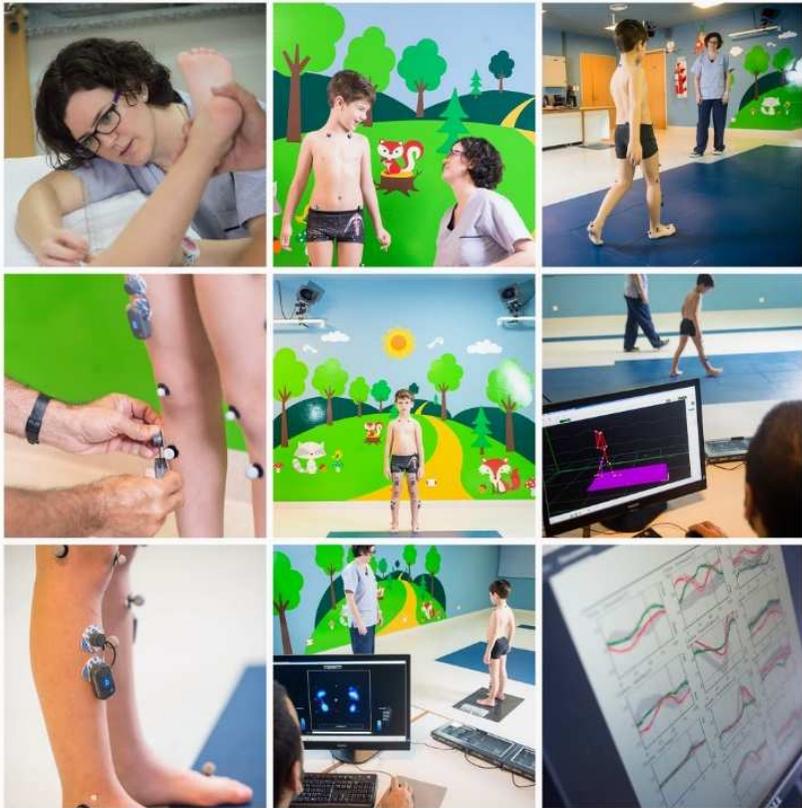




**Modelos de  
análisis de marcha:  
desarrollo actual y futuro**

# Modelos de análisis de marcha

# ANÁLISIS CLÍNICO DE LA MARCHA (CGA)



## Examen físico

Rangos de Movimiento. CMS. Fuerza. Tono. Alineación postural

## Cinemática

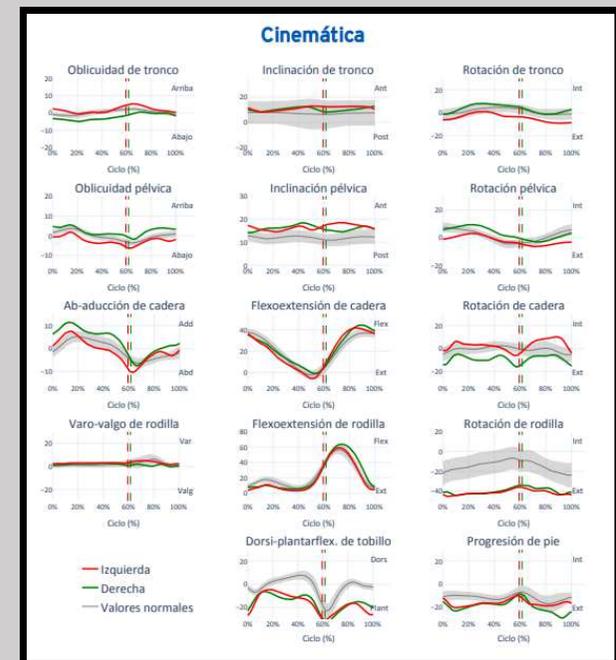
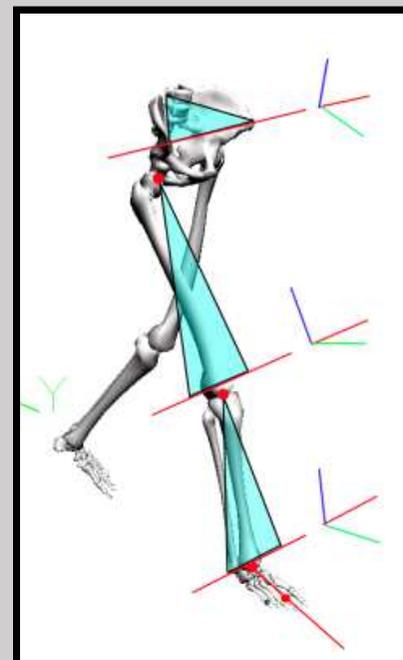
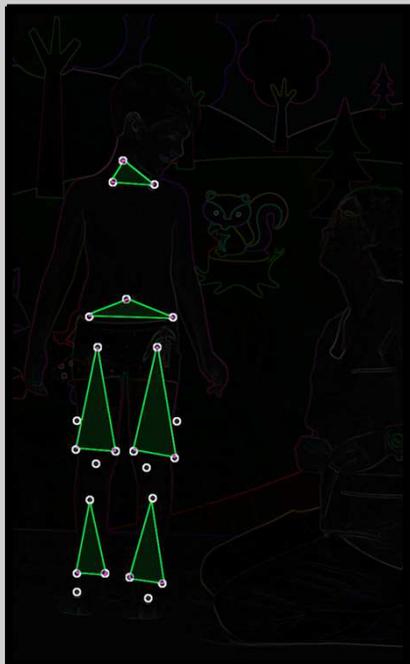
Parámetros distancia tiempo, rotaciones 3D articulaciones

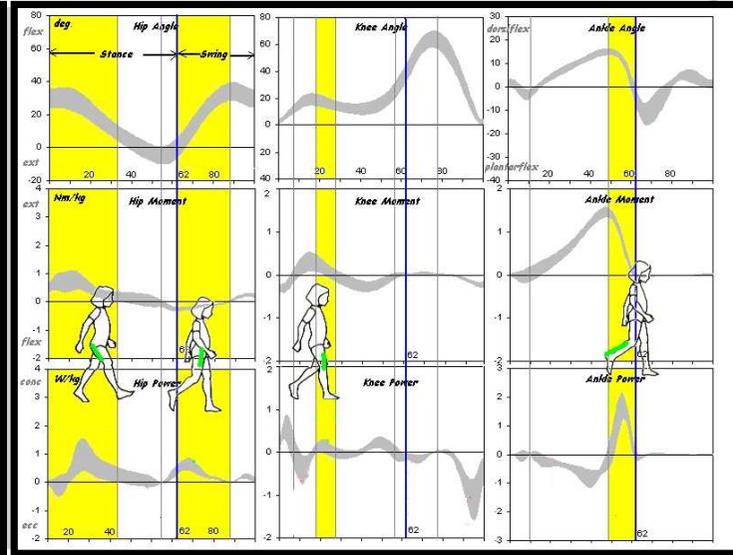
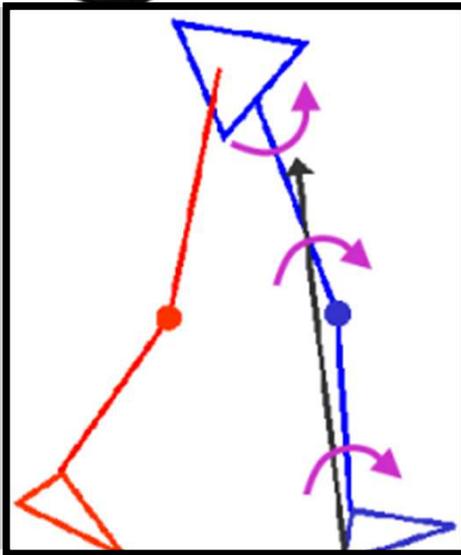
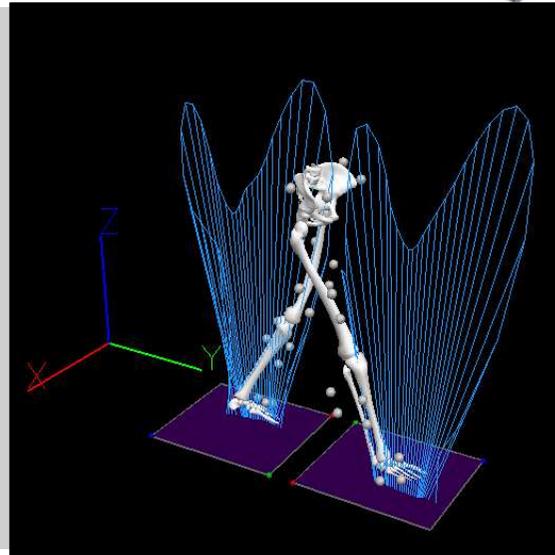
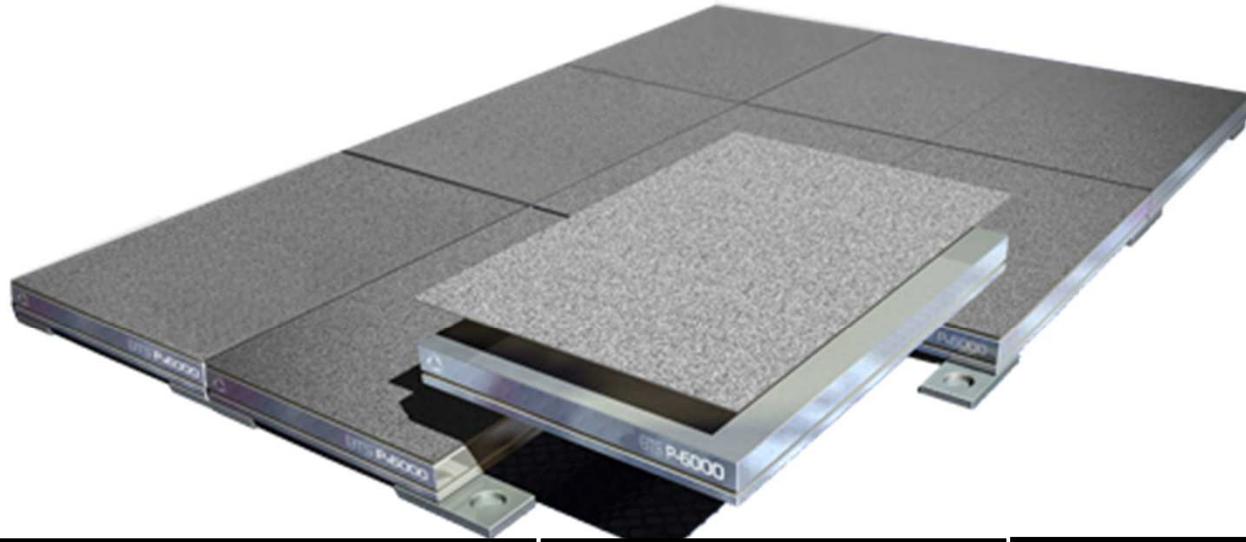
## Cinética

Fuerza, momento, potencia, presiones plantares

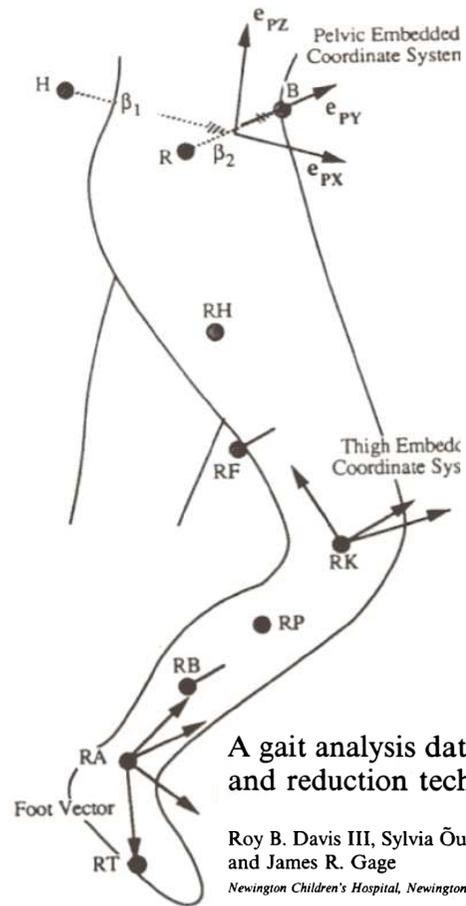
## Dinámica muscular

EMG, longitud y velocidad de acortamiento muscular.





# CONVENTIONAL GAIT MODEL



Validación

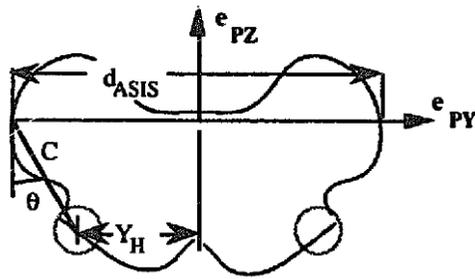
Simpleza

Comprensión

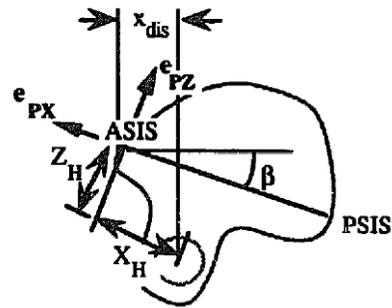
Utilidad clínica

# Debilidades del CGM y desarrollos actuales que lo mejoran

# CENTRO DE ROTACIÓN DE CADERA



Coronal Plane View



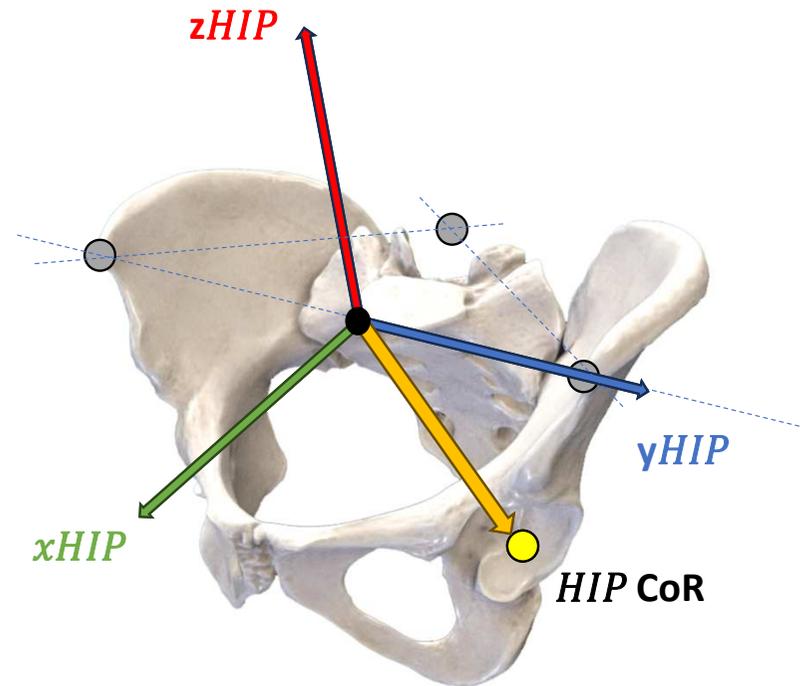
Sagittal Plane View

**Medidas antropométricas:**  
**Largo de pierna, ancho de pelvis, altura de pelvis**

$$x_{HIP} = -x_{dis} \cdot \cos \beta + C \cdot \cos \theta \cdot \sin \beta$$

$$y_{HIP} = S \cdot [C \cdot \sin \theta - h_{ASIS} / 2]$$

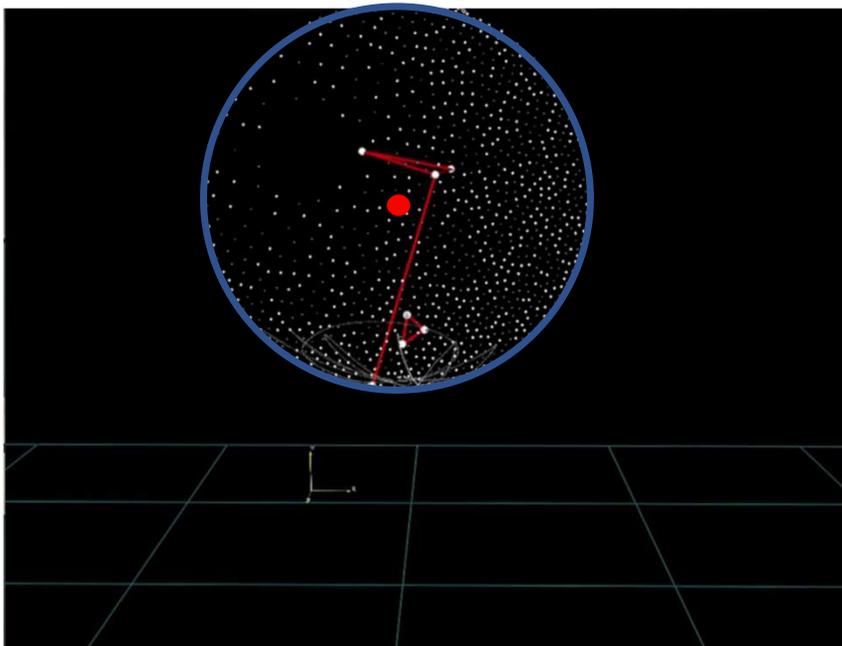
$$z_{HIP} = -x_{dis} \cdot \sin \beta - C \cdot \cos \theta \cdot \cos \beta$$



# CALIBRACIÓN FUNCIONAL

(Leardini 1999; Schwartz and Rozumalski 2005; Chang and Pollard 2007a; Ehrig et al. 2006).

**SCoRE: Symmetrical Center of Rotation Estimation**



Journal of Biomechanics ■■■■■

JOURNAL  
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BIOMECHANICS

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

A survey of formal methods for determining the centre of rotation of ball joints

Rainald M. Ehrig<sup>a,b</sup>, William R. Taylor<sup>a</sup>, Georg N. Duda<sup>a,\*</sup>, Markus O. Heller<sup>a</sup>

<sup>a</sup>Research Laboratory, Center for Musculoskeletal Surgery, Charité – Universitätsmedizin Berlin, Augustenburger Platz 1, D-13353 Berlin, Germany

<sup>b</sup>Zuse Institute Berlin (ZIB), Berlin, Germany

Accepted 3 October 2005



Journal of Biomechanics 39 (2006) 1096–1106

JOURNAL  
OF  
BIOMECHANICS

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

An optimized protocol for hip joint centre determination using the functional method

Valentina Camomilla<sup>\*</sup>, Andrea Cereatti, Giuseppe Vannozzi, Aurelio Cappozzo

Department of Human Movement and Sport Sciences, Istituto Universitario di Scienze Motorie, Piazza Lauro de Bosis, 15, 00194 Roma, Italy

Accepted 8 February 2005

# MEJORES MÉTODOS REGRESIVOS

Harrington et al. 2007; Sangeux et al. 2011; Peters et al. 2012



Journal of Biomechanics 40 (2007) 595–602

JOURNAL OF BIOMECHANICS

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

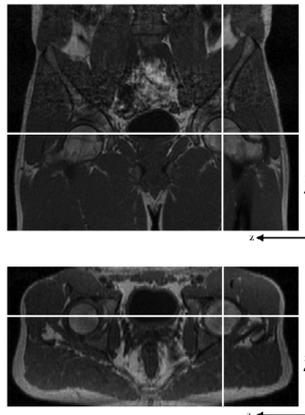
Prediction of the hip joint centre in adults, children, and patients with cerebral palsy based on magnetic resonance imaging

M.E. Harrington<sup>a</sup>, A.B. Zavatsky<sup>b,\*</sup>, S.E.M. Lawson<sup>b</sup>, Z. Yuan<sup>b</sup>, T.N. Theologis<sup>a</sup>

<sup>a</sup>The Oxford Gait Laboratory, Nuffield Orthopaedic Centre, Oxford, UK

<sup>b</sup>Department of Engineering Science, University of Oxford, Parks Road, Oxford OX1 3PJ, UK

Accepted 1 February 2006



$$\hat{x} = -0.24PD - 9.9,$$

$$\hat{y} = -0.16PW - 0.04LL - 7.1$$

$$\hat{z} = 0.28PD + 0.16PW + 7.9.$$

Imágenes de RMN

8 adultos

14 niños sanos

10 niños con PC diparesia espástica



Contents lists available at SciVerse ScienceDirect

Gait & Posture

journal homepage: [www.elsevier.com/locate/gaitpost](http://www.elsevier.com/locate/gaitpost)



A comparison of hip joint centre localisation techniques with 3-DUS for clinical gait analysis in children with cerebral palsy

Alana Peters<sup>a,b,\*</sup>, Richard Baker<sup>b,c,d,e</sup>, M.E. Morris<sup>b</sup>, Morgan Sangeux<sup>a,b,d</sup>

<sup>a</sup>Royal Children's Hospital, 52 Flemington Road, Parkville, Victoria 3052, Australia

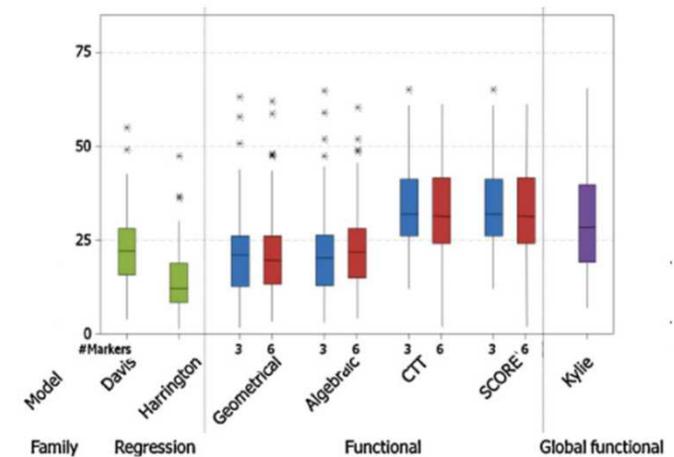
<sup>b</sup>The University of Melbourne, Victoria 2010, Australia

<sup>c</sup>University of Salford, Salford, Greater Manchester M5 4WT, United Kingdom

<sup>d</sup>Murdoch Childrens Research Institute, Royal Children's Hospital, Flemington Road, Parkville, Victoria 3052, Australia

<sup>e</sup>La Trobe University, Melbourne, Victoria 3086, Australia

Overall discrepancy (mm)



# RSCoRe

Journal of Biomechanics 129 (2021) 110810



Contents lists available at ScienceDirect

Journal of Biomechanics

journal homepage: [www.elsevier.com/locate/jbiomech](http://www.elsevier.com/locate/jbiomech)



Short communication

## A regularized functional method to determine the hip joint center of rotation in subjects with limited range of motion

Emiliano Pablo Ravera<sup>a,b,\*</sup>, Victoria Peterson<sup>c</sup>

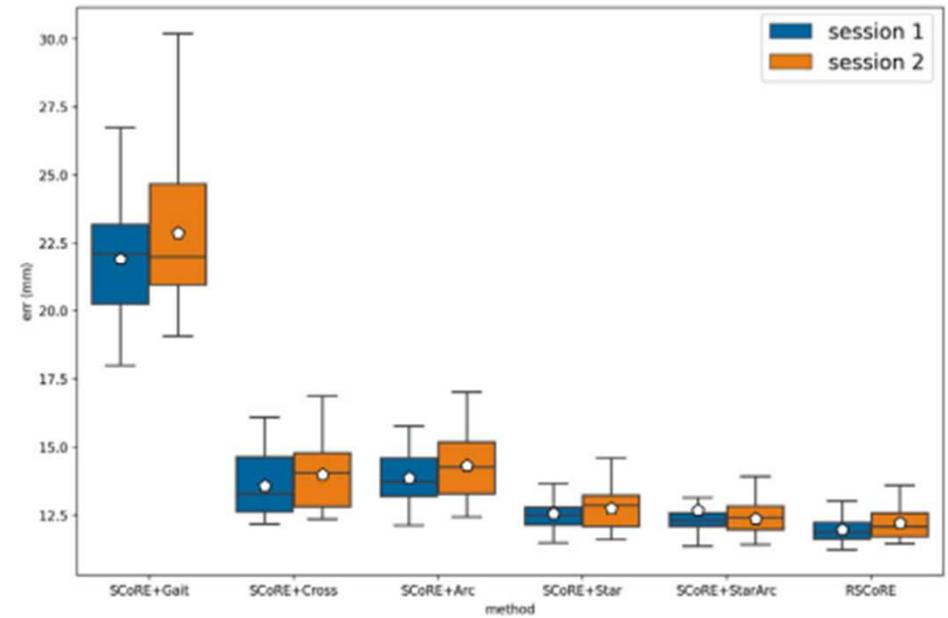
<sup>a</sup> Group of Analysis, Modeling, Processing and Clinician Implementation of Biomechanical Signals and Systems, Bioengineering and Bioinformatics Institute, CONICET-UNER, Oro Verde, Argentina

<sup>b</sup> Human Movement Research Laboratory, School of Engineering, National University of Entre Ríos (UNER), Oro Verde, Argentina

<sup>c</sup> Applied Mathematics Institute (IMAL), CONICET-UNL, Santa Fe, Argentina



E.P. Ravera and V. Peterson



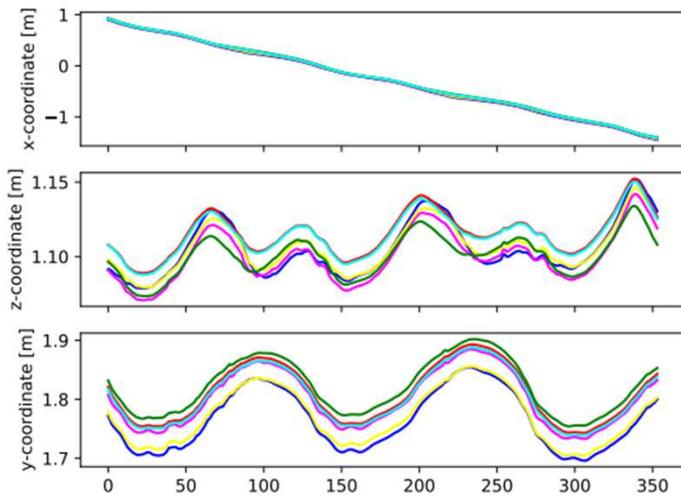
# RSCoRe. Pruebas en MMC

The SCoRe residual: A quality index to assess the accuracy of joint estimations

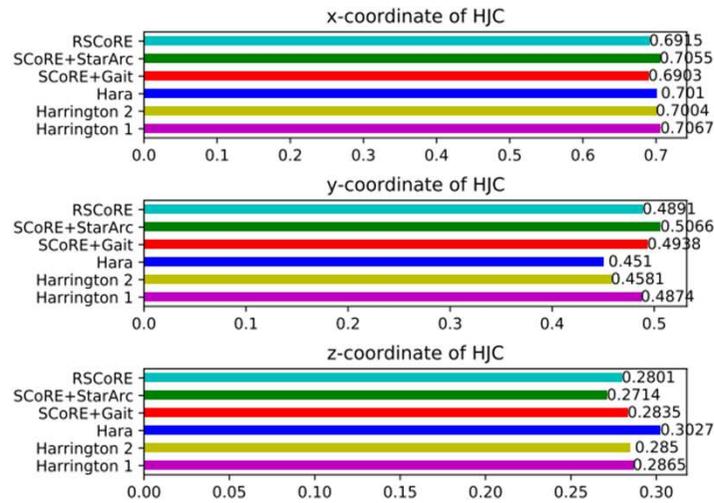
Rainald M. Ehrig<sup>b,1</sup>, Markus O. Heller<sup>a,1</sup>, Stefan Kratzstein<sup>a</sup>, Georg N. Duda<sup>a</sup>, Adam Trepczynski<sup>a</sup>, William R. Taylor<sup>a,\*</sup>

<sup>a</sup>Julius Wolff Institute, Center for Sports Science and Sports Medicine Berlin (CSSB), Charité—Universitätsmedizin Berlin, Philippstr. 13, Haus 11, D-10115 Berlin, Germany  
<sup>b</sup>Zuer Institute Berlin (ZIB), Berlin, Germany

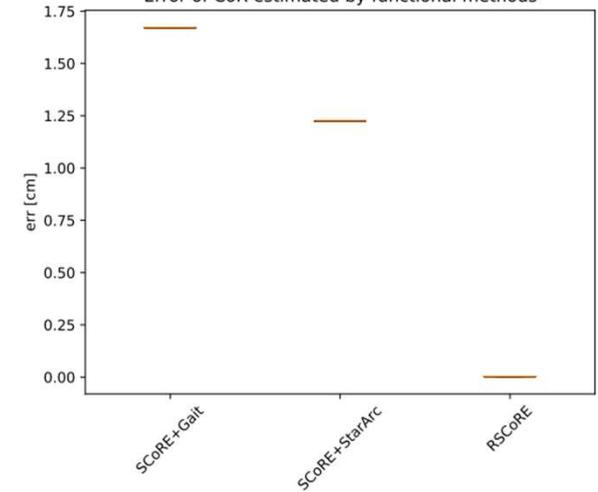
HJC estimation by SCoRE and Regularized SCoRE



HJC estimated by Predictive and functional methods



Error of CoR estimated by functional methods



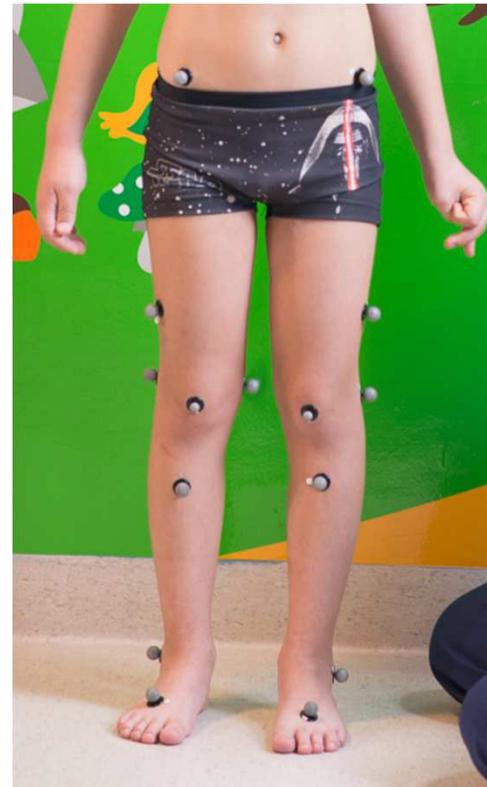
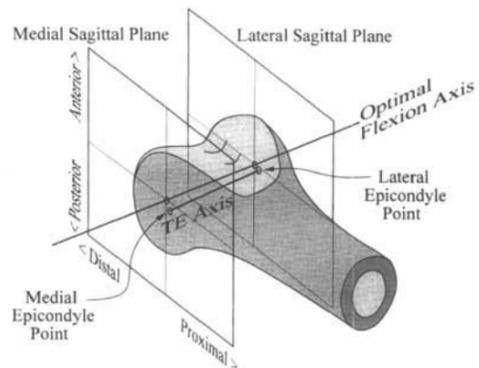
# PLANO CORONAL DEL FÉMUR

## EJE DE ROTACIÓN DE RODILLA - MÉTODO CONVENCIONAL

CLINICAL ORTHOPAEDICS AND RELATED RESEARCH  
Number 356, pp 111-118  
© 1998 Lippincott Williams & Wilkins

### The Transepicondylar Axis Approximates the Optimal Flexion Axis of the Knee

*David L. Churchill, PhD; Stephen J. Incavo, MD;  
Christopher C. Johnson, BS; and Bruce D. Beynnon, PhD*



# MÉTODO DE CALIBRACIÓN FUNCIONAL

(Baker et al. 1999; Schwartz and Rozumalski 2005; Chang and Pollard 2007b; Ehrig et al. 2007)

**SARA: Symmetrical axis of rotation approach**



Journal of Biomechanics 40 (2007) 2150–2157

JOURNAL  
OF  
BIOMECHANICS

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www.JBiomech.com

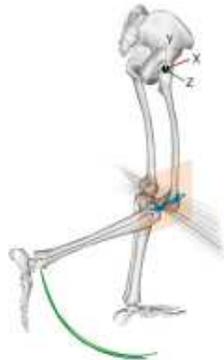
A survey of formal methods for determining functional joint axes

Rainald M. Ehrig<sup>b</sup>, William R. Taylor<sup>a</sup>, Georg N. Duda<sup>a,\*</sup>, Markus O. Heller<sup>a</sup>

<sup>a</sup>Center for Musculoskeletal Surgery, Charité – Universitätsmedizin Berlin, Augustenburger Platz 1, D-13353 Berlin, Germany

<sup>b</sup>Zuse Institute Berlin (ZIB), Berlin, Germany

Accepted 26 October 2006



# Diferencias con 3DUS



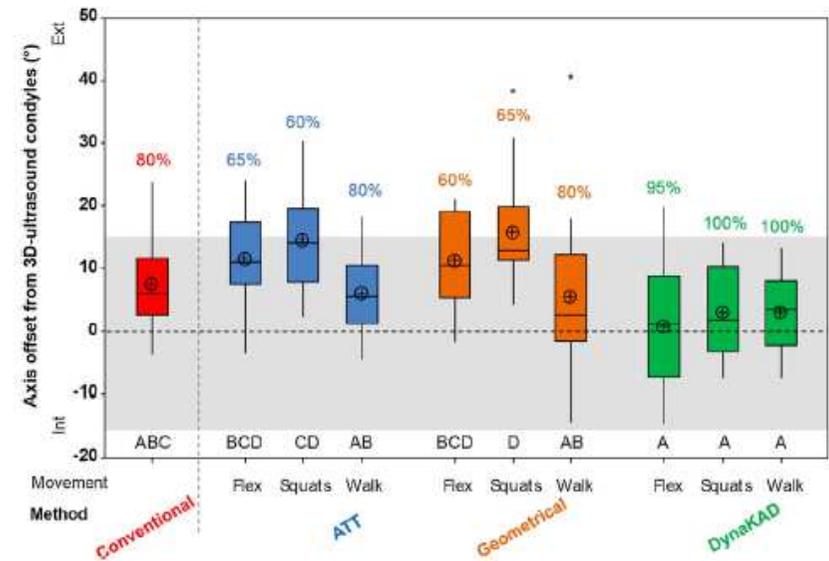
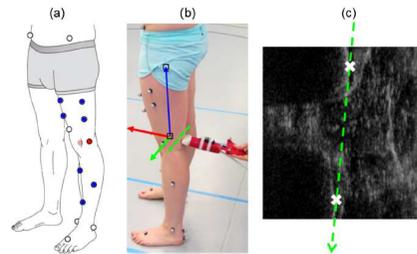
## Defining the medial-lateral axis of an anatomical femur coordinate system using freehand 3D ultrasound imaging

Elyse Passmore<sup>a,b,c,\*</sup>, Morgan Sangeux<sup>a,b,c</sup>

<sup>a</sup> Hugh Williamson Gait Analysis Laboratory, The Royal Children's Hospital, Melbourne, Australia

<sup>b</sup> Murdoch Childrens Research Institute, Melbourne, Australia

<sup>c</sup> Department of Mechanical Engineering, The University of Melbourne, Australia



# Marcador de Patela

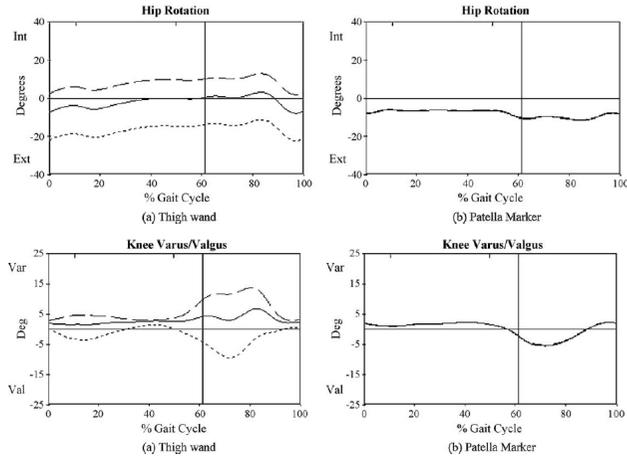
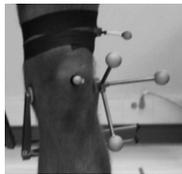


Winner of GCMAS Best Paper Award 2009

## The effect of static standing posture on dynamic walking kinematics: Comparison of a thigh wand versus a patella marker

Mark L. McMulkin\*, Andi B. Gordon

Walter E. Griffin and Agnes M. Griffin Motion Analysis Laboratory, Shriners Hospitals for Children, 911 W. 5th, Spokane, WA 99204, USA



Available online at [www.sciencedirect.com](http://www.sciencedirect.com)



Gait & Posture 27 (2008) 530–534



[www.elsevier.com/locate/gaitpost](http://www.elsevier.com/locate/gaitpost)

## Use of a patella marker to improve tracking of dynamic hip rotation range of motion

Tishya A.L. Wren<sup>a,b,\*</sup>, K. Patrick Do<sup>a</sup>, Reiko Hara<sup>a</sup>,  
Susan A. Rethlefsen<sup>a</sup>

<sup>a</sup> Childrens Orthopaedic Center, Childrens Hospital Los Angeles, Los Angeles, CA, USA

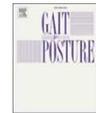
<sup>b</sup> Departments of Orthopaedics, Radiology, and Biomedical Engineering, University of Southern California, Los Angeles, CA, USA



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Gait & Posture

journal homepage: [www.elsevier.com/locate/gaitpost](http://www.elsevier.com/locate/gaitpost)



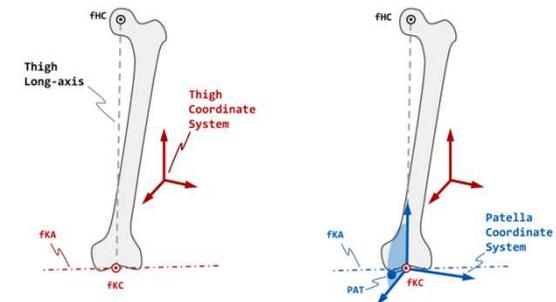
Full length article

## A patella marker to improve hip and knee kinematics for models with functionally defined joint axes

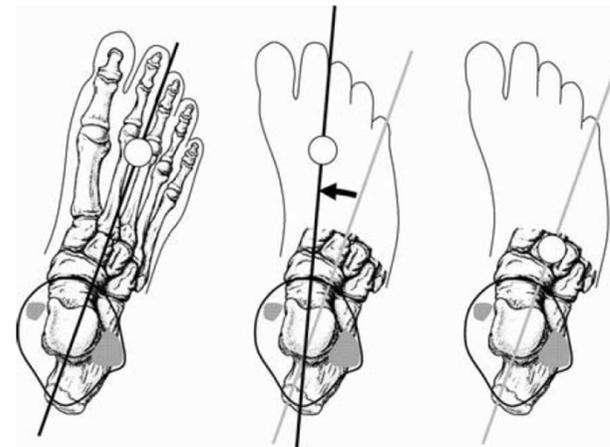
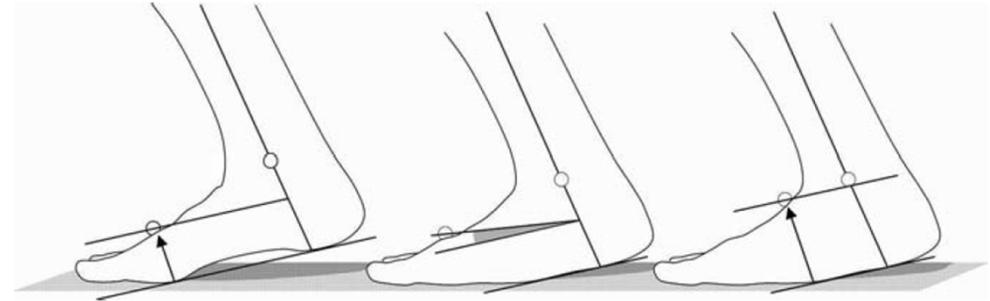
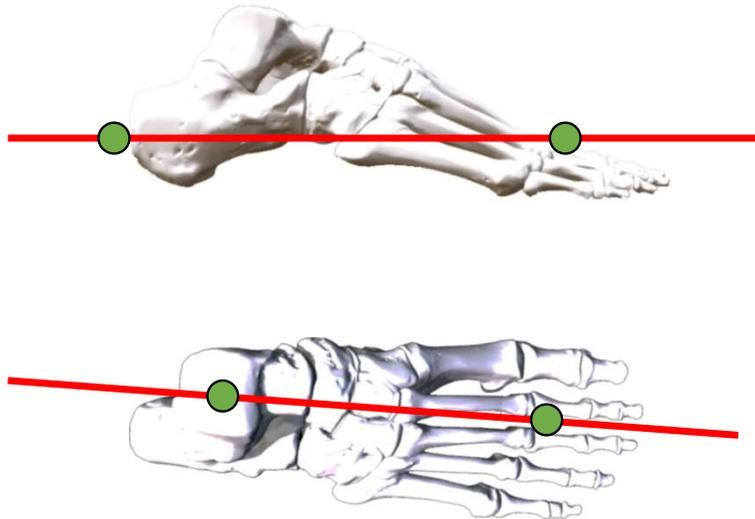
Andrew J. Ries<sup>a,\*</sup>, Michael H. Schwartz<sup>a,b</sup>

<sup>a</sup> Center for Gait and Motion Analysis, Gillette Children's Specialty Healthcare, St Paul, MN, United States

<sup>b</sup> Department of Orthopedic Surgery, University of Minnesota, Minneapolis, MN, United States



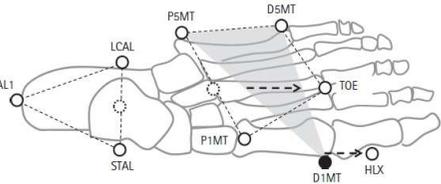
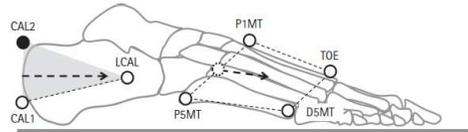
# MODELO DE PIE DEMASIADO SIMPLE



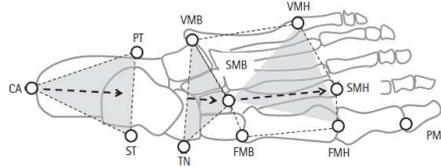
Harris, Gerald & Smith, Peter. (2007). Foot and Ankle Motion Analysis: Clinical Treatment and Technology.

# MODELOS MULTISEGMENTO

## Oxford Foot Model



## IOR Model



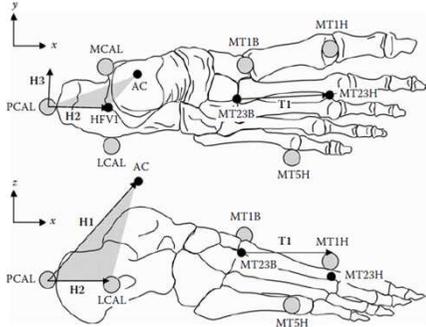
## SHCG foot model



A multi-segment foot model based on anatomically registered technical coordinate systems: Method repeatability in pediatric feet

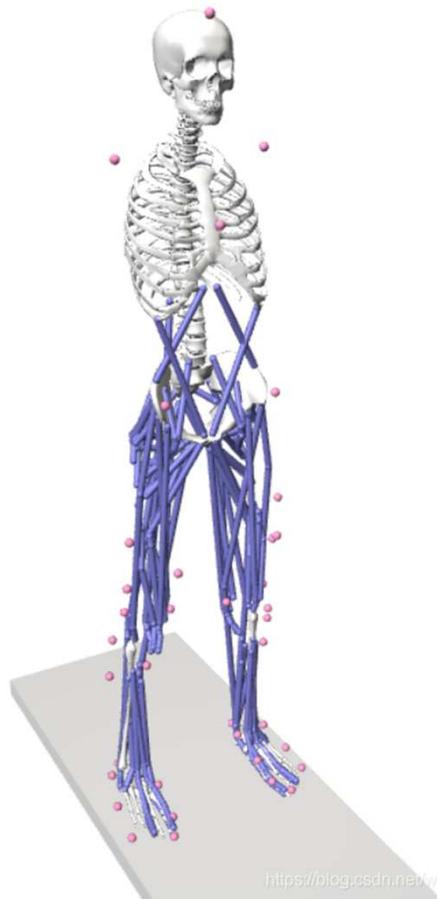
Prabhav Saraswat<sup>a</sup>, Bruce A. MacWilliams<sup>a,b,\*</sup>, Roy B. Davis<sup>c</sup>

<sup>a</sup> Shriners Hospitals for Children, Salt Lake City, UT, USA  
<sup>b</sup> Department of Orthopaedic Surgery, University of Utah, Salt Lake City, UT, USA  
<sup>c</sup> Shriners Hospitals for Children, Greenville, SC, USA



# El futuro del modelado

# MODELADO MUSCULOESQUELÉTICO



[https://blog.csdn.net/weixin\\_45367051](https://blog.csdn.net/weixin_45367051)

The role of estimating muscle-tendon lengths and velocities of the hamstrings in the evaluation and treatment of crouch gait

Allison S. Arnold<sup>a,\*</sup>, May Q. Liu<sup>a</sup>, Michael H. Schwartz<sup>c</sup>,  
Sylvia Öunpuu<sup>d</sup>, Scott L. Delp<sup>a,b</sup>

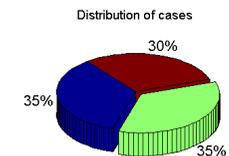
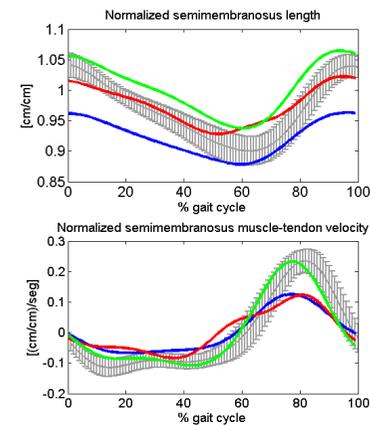
<sup>a</sup>Department of Mechanical Engineering, Stanford University, Stanford, CA 94305-5450, USA

<sup>b</sup>Department of Bioengineering, Stanford University, Stanford, CA, USA

<sup>c</sup>Center for Gait and Motion Analysis, Gillette Children's Specialty Healthcare, St. Paul, MN, USA

<sup>d</sup>Center for Motion Analysis, Connecticut Children's Medical Center, Hartford, CT, USA

Received 26 July 2004; received in revised form 28 February 2005; accepted 17 March 2005

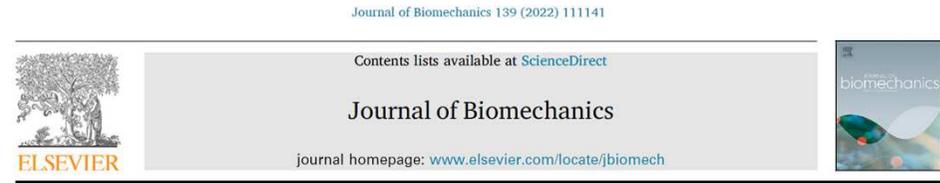
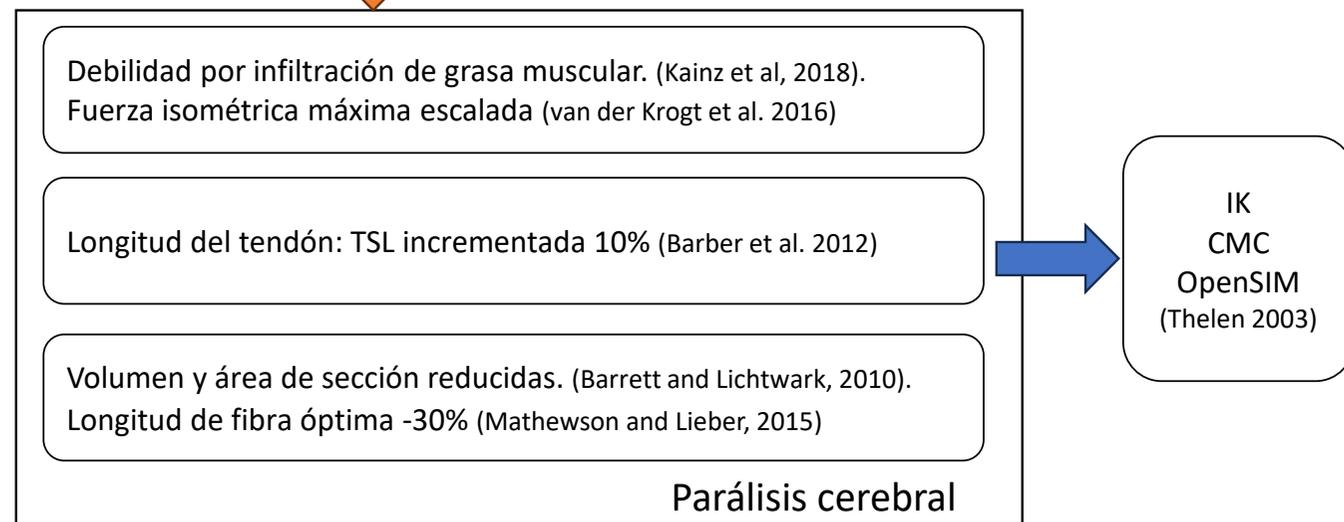
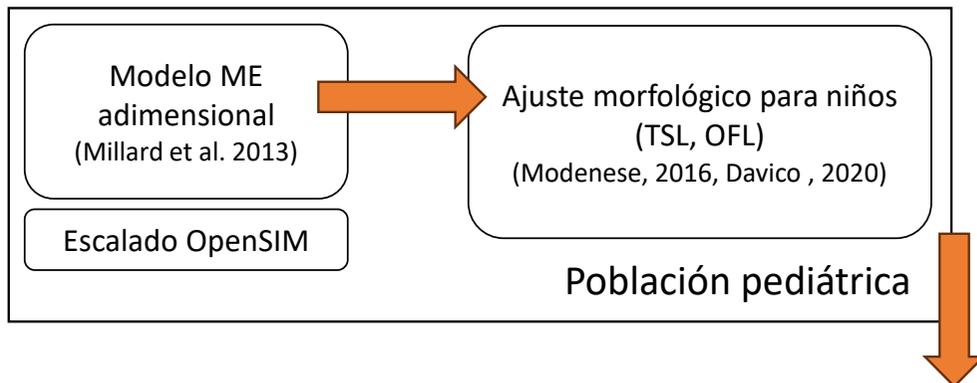


— Ref.  
— Short and slow hamstrings  
— Slow hamstrings  
— Not short and not slow hamstrings

Delp, S.L., Anderson, F.C., Arnold, A.S., Loan, P., Habib, A., John, C.T., Guendelman, E., Thelen, D.G.

OpenSim: Open-source software to create and analyze dynamic simulations of movement. IEEE Transactions on Biomedical Engineering, 54(11), pp 1940-1950. (2007)

# MODELOS ESPECIFICOS DE POBLACIÓN



Individual muscle force–energy rate is altered during crouch gait: A neuro-musculoskeletal evaluation

Emiliano Pablo Ravera<sup>a,b,\*</sup>, Marcos José Crespo<sup>c</sup>, Adam Rozumalski<sup>d</sup>

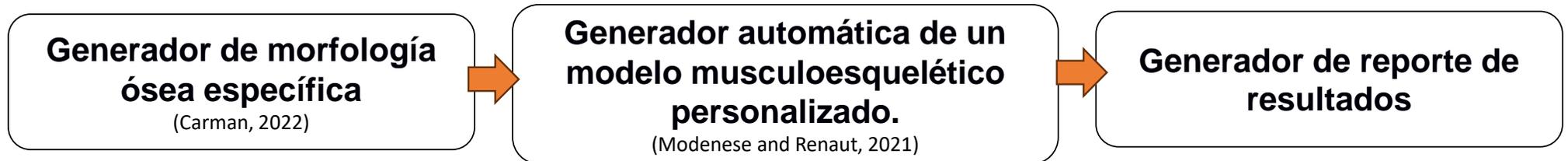
<sup>a</sup> Group of Analysis, Modelling, Processing and Clinician Implementation of Biomechanical Signals and Systems, Bioengineering and Bioinformatics Institute, CONICET-UNER, Oro Verde, Argentina

<sup>b</sup> Human Movement Research Laboratory, School of Engineering, National University of Entre Ríos (UNER), Oro Verde, Argentina

<sup>c</sup> Laboratorio de análisis de marcha y movimiento, LAMM y Tecnología en rehabilitación, Clínica de tecnología asistiva, TA. Fleni, Escobar, Argentina

<sup>d</sup> The James R. Gage Center for Gait & Motion Analysis, Gillette Children's Specialty Healthcare, St. Paul, MN, United States of America

# MODELOS ESPECIFICOS DE PACIENTE



Soluciones Innovadoras para Desafíos de Software



www.nature.com/scientificreports

**scientific reports**

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**OPEN** Morphological variation in paediatric lower limb bones

Laura Carman<sup>1</sup>, Thor F. Besier<sup>1,2</sup> & Julie Choise<sup>1,2</sup>

Contents lists available at ScienceDirect

**Journal of Biomechanics**

journal homepage: [www.elsevier.com/locate/jbiomech](http://www.elsevier.com/locate/jbiomech)  
[www.JBiomech.com](http://www.JBiomech.com)

Automatic generation of personalised skeletal models of the lower limb from three-dimensional bone geometries

Luca Modenese<sup>a,\*</sup>, Jean-Baptiste Renault<sup>b</sup>

<sup>a</sup>Department of Civil and Environmental Engineering, Imperial College London, UK  
<sup>b</sup>Aix-Marseille University, CNRS, ISM UMR 7287, 13009 Marseille, France

Check for updates

# CONCLUSIONES



**Gracias por su atención!**

[mcrespo@fleni.org.ar](mailto:mcrespo@fleni.org.ar)