AreYouFine

ISPGR World Congress 2015

INTERNATIONAL E-LEARNING IN ASSESSMENT OF PERSONAL INJURY BASED ON BIOMECHANICAL ANALYSIS TO IMPROVE SUSTAINABILITY AND EFFICACY OF THE HEALTHCARE SYSTEM –RESEARCH OUTCOMES FROM AREYOUFINE?

D. Amram (SSSUP); J.M. Baydal (IBV); I., Bermejo (IBV); S.D. Ferrara (IALM); B. Guiddi (SSSUP); E. Pizzorno (CEREDOC); R. Portilla (IBV); D. Roman-Liu (CIOP); G., Viel (IALM); J.I. Muñoz-Barús (USC)

IBV INSTITUTO DE BIOMECÁNICA DE VALENCIA

Instituto de Biomecánica de Valencia, Spain
email: juan.lopez@ibv.upv.es

BACKGROUND

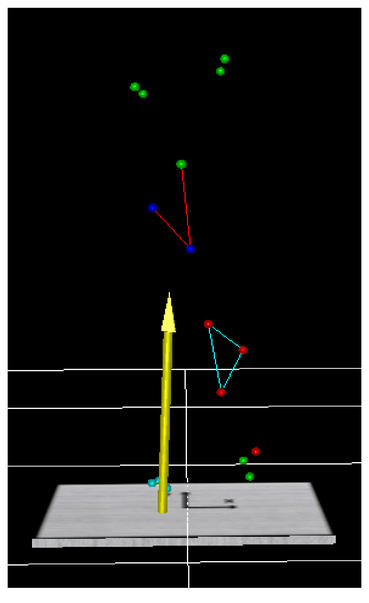
- The use of **high heel shoes (HHS)** disturbs the natural position of foot causing an alteration of the temporal–spatial parameters of gait, which may generate or aggravate musculoskeletal injuries.
- The influence of the **heel height** in several gait parameters have already been reported, however no previous studies analyzed the changes in the reaction forces and joint angle waveforms.
- **Functional Principal Component Analysis (FPCA)** could be advantageous in automatically extracting the relevant information for characterizing the effect of heel's height in HHS gait.

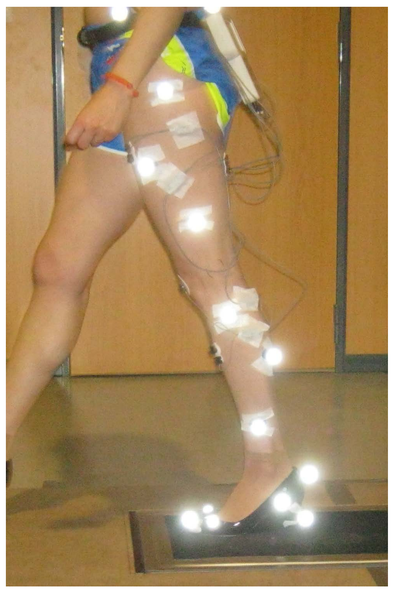
GOALS

1. The **aim** of the study was to analyze the **influence of heel height** on gait biomechanics by means of a **functional principal components analysis** (FPCA).

METHODS

- Knee and ankle kinematics and ground reaction forces (GRF) were recorded for **8 women** walking with **two pairs of HHS**.
- The two shoes had the same design characteristics, with the exception of the **heel height** (**80mm and 125mm**).
- Only the **stance phase** was analyzed.



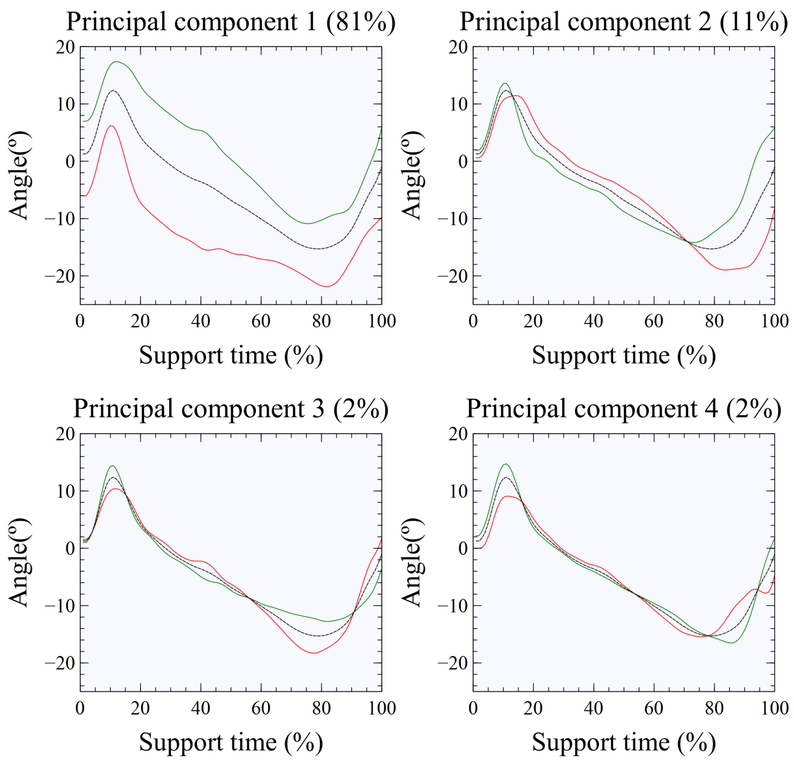


- **80 trials** were collected (5 rep. with each shoe, in randomized order).
- **Data processing** consisted of :
  - ✓ Smoothing by a B-splines base and time scale normalization [1].
  - ✓ **Functional PCA** of continuous records of measured angles and GRF [2].
  - ✓ One way **repeated measures ANOVA** was made using the FPCA **scores**.
  - ✓ The **marginal mean curves** were reconstructed using the scores that showed significant differences.

RESULTS

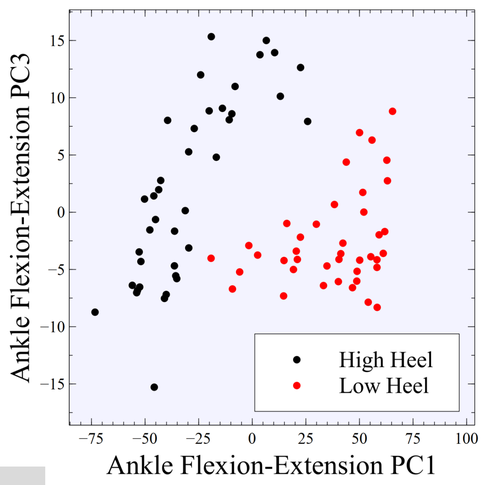
1. FPCA to analyze the variability in the 80 trials of HHS gait:

- FPCA was carried out for the following **functions**: vertical and horizontal GRF, knee FE, ankle FE, ankle ABD, ankle ROT.
- 4 PC were extracted (minimum **95% of the variability** explained)



- For each subject and shoe (high heel/ low heel), the **mean of the FPC scores** for **the 5 repetitions** was calculated.
- For every function in the analysis, **one way repeated measures ANOVA** was made introducing the heel height as factor and the FPC score as the dependent variable.

2. Analysis of the differences in the FPA scores of gait with the 2 shoes:



- **Significant differences** were found between the high and the low heel in **all the functions** in analyzed.

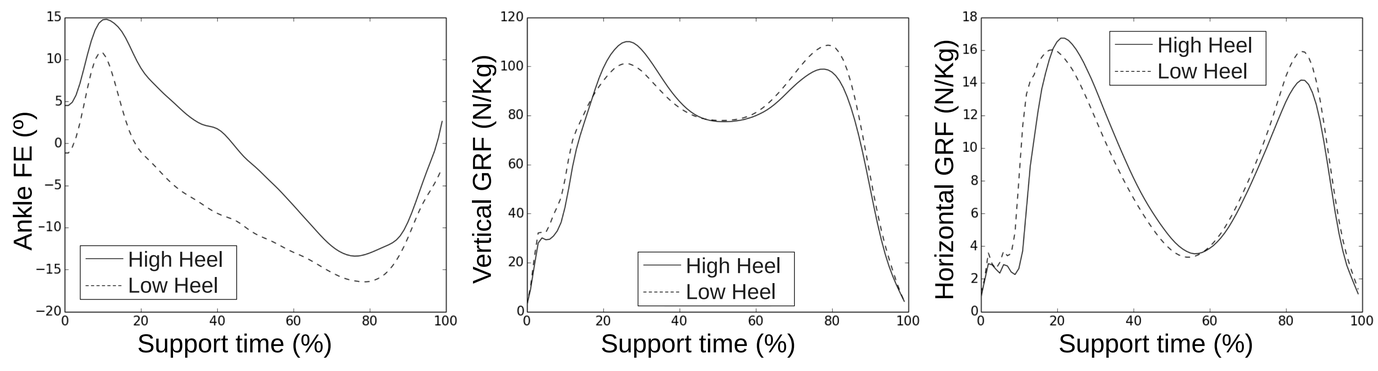
p value of the One way repeated measures ANOVA of the FPC scores for each waveform

Function	PC1	PC2	PC3	PC4
Nkee FE	<0,01			
Ankle FE	<0,01	<0,01	<0,01	
Ankle ABD	<0,01			
Ankle ROT	<0,01	<0,01	<0,01	<0,01
Vert. GRF	<0,01	<0,01	<0,01	
Horiz. GRF	<0,01		<0,01	

3. Reconstruction of the marginal mean curves for gait with high and low shoes:

FPCA $f_i(t) = F(t) + a_{i1} PC_1(t) + a_{i2} PC_2(t) + \ldots \ldots a_{im} PC_m(t)$

- **Curves for high and low heels** were obtained for each variable using only the PCs significantly different to build the functions.



CONCLUSIONS

- Using **functional data analysis** is advantageous for the statistical treatment of multiple time waveforms.
- **FPCA** allows **reducing the information** of a family of curves to a small set of scalar variables, automatically and **without loss** of the original information that is contained in the raw signals.
- The **scores** of the principal components allowed to **distinguish** clearly between HHS gait using two shoes with **different height**. Consistent differences were found in **gait biomechanics**, both in the joint **angles** and in the **GRF**.

REFERENCES

[1] Ramsay J.O., Silverman B.W. (2005) Functional data analysis. Springer, New York.
[2] Epifanio, I., et al. Med Biol Eng Comp 2008; 46:551–561.

ACKNOWLEDGMENTS

This work is part of the activities driven by **ADDFactor** (ADvanced Digital technologies and virtual engineering for mini-Factories) project, funded by the EU (FP7/2007-2013) under grant agreement n° [609386].

ADD·FACTOR
SEVENTH FRAMEWORK PROGRAMME