

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?

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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.

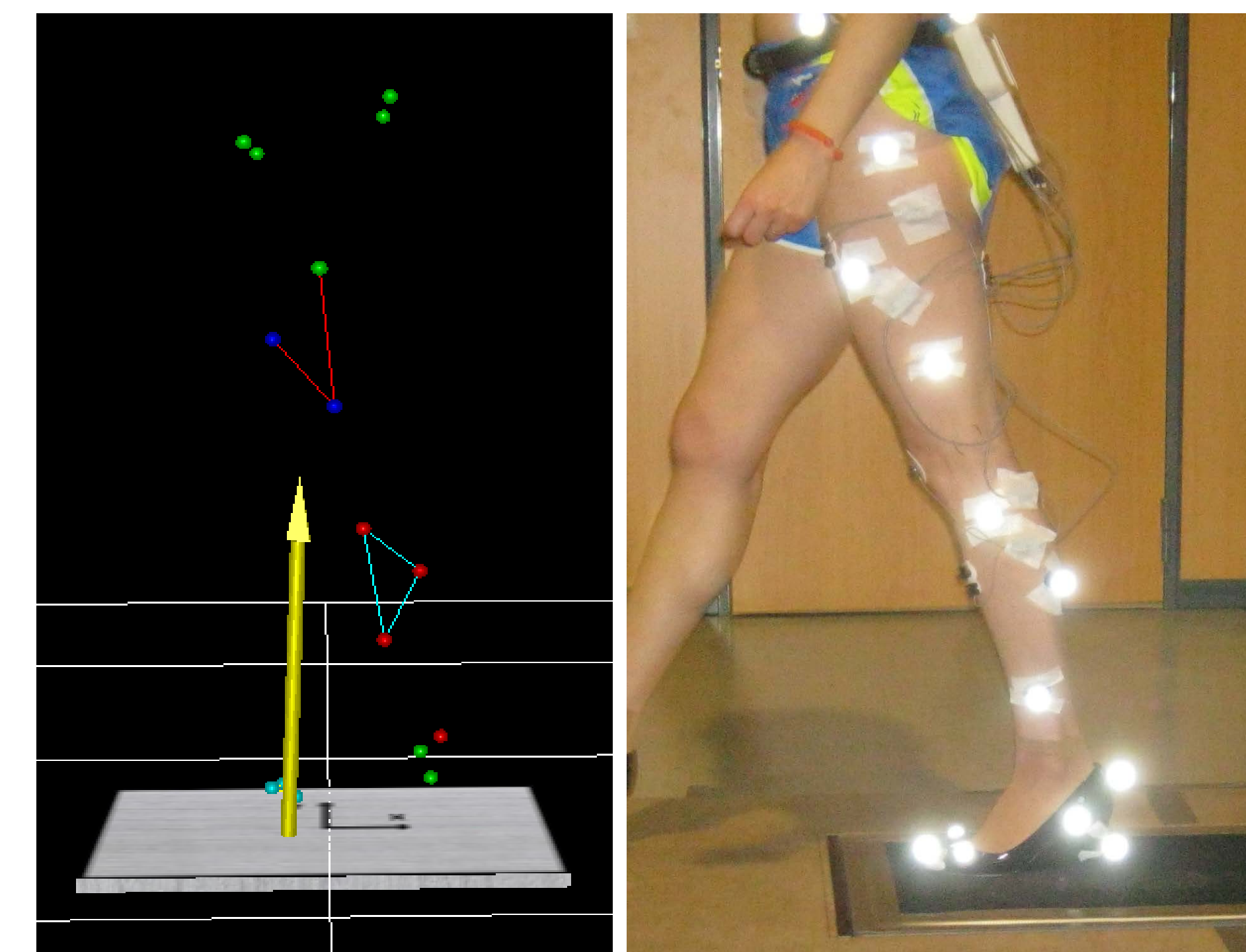
- 80 trials** were collected (5 rep. with each shoe, in randomized order).
- Data processing** consisted of :
 - ✓ Smoothing by a B-splines base and time scale normalization [1].
 - ✓ **Functional PCA** of continuous records of measured angles and GRF [2].
 - ✓ One way **repeated measures ANOVA** was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

GOALS

- 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

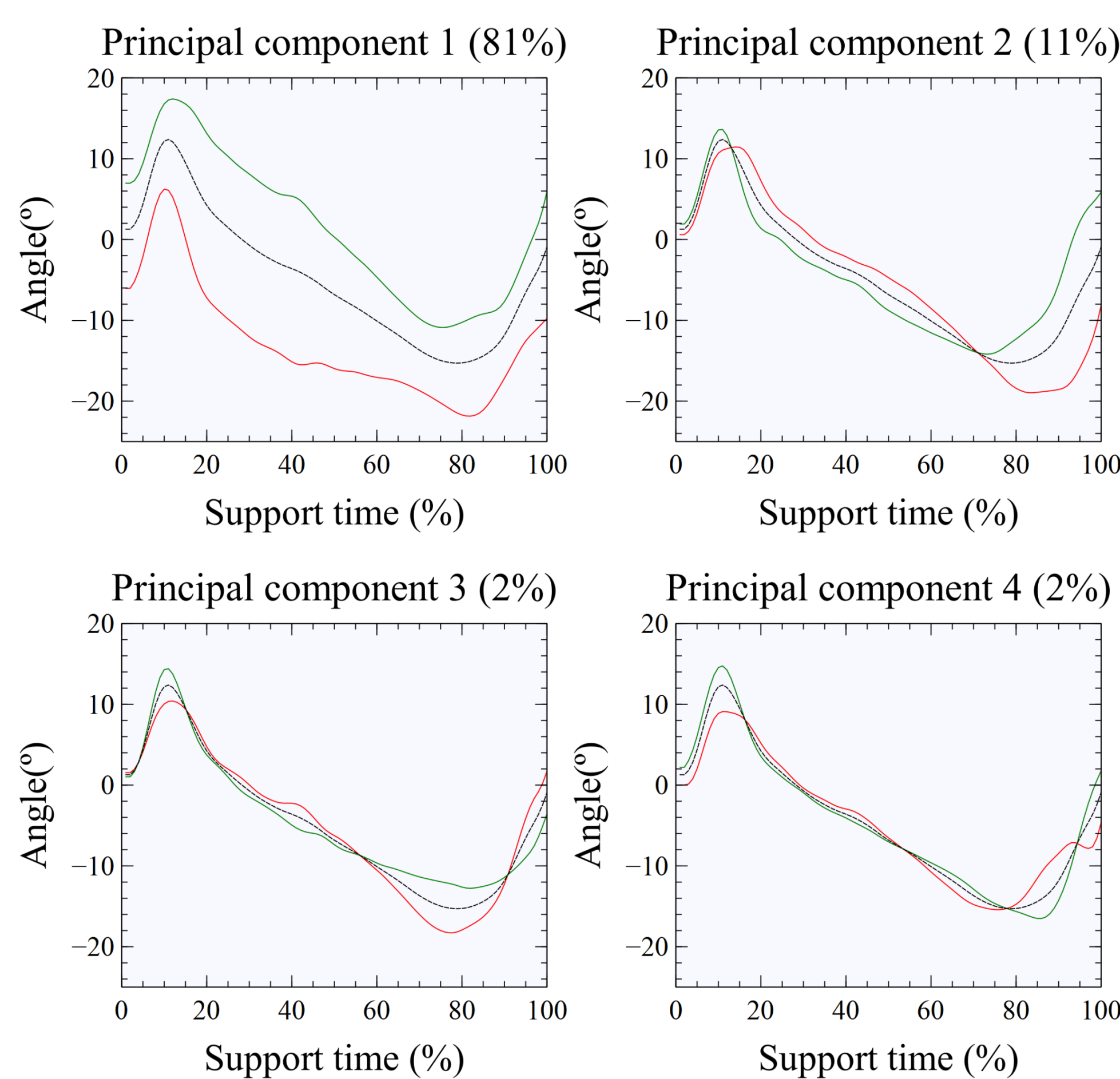
- Knee and ankle kinematics and ground reaction forces (GRF) were recorded for **8 women** walking with **two pairs of HHS**.
- The two shoes had the same design characteristics, with the exception of the **heel height (80mm and 125mm)**.
- Only the **stance phase** was analyzed.



RESULTS

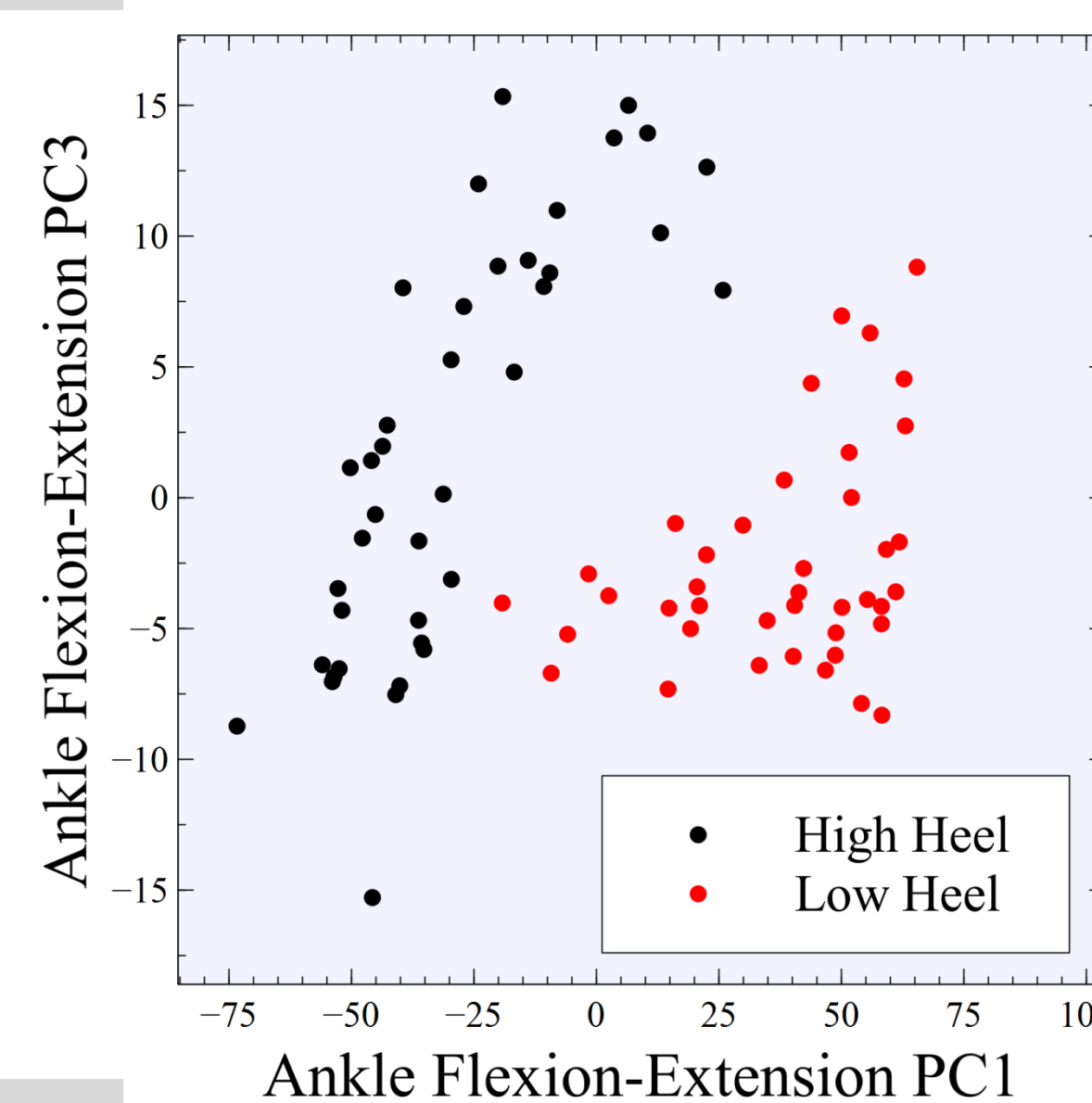
1. FPCA to analyze the variability in the 80 trials of HHS gait:

- 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 FPCA scores of gait with the 2 shoes:



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

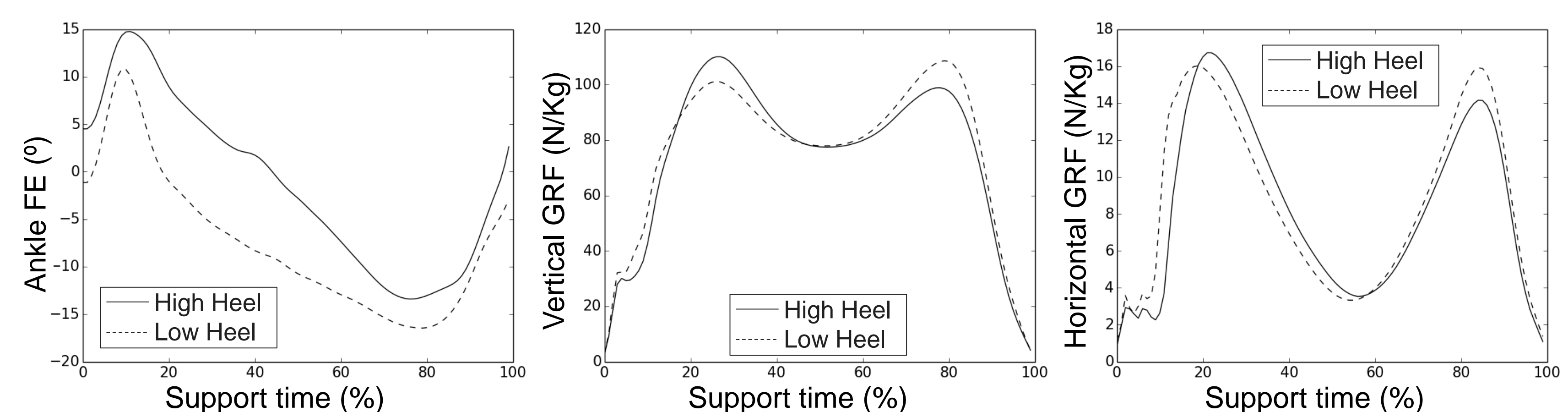
p value of the One way repeated measures ANOVA of the FPC scores for each waveform

Function	PC1	PC2	PC3	PC4
Nknee 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:

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

- 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

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

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