Meta Products towards a “gait/running style app”

Martin Daumer, Andreas N. Schneider, Damian Mrowca, Rui Ding, Han Gao, Christian Lederer

Background: The individual running style has an impact on the running performance as well as the running injury risk. In order to increase the performance and lower the injury risk, runners should be educated towards a healthy running style. But before advices can be made it is crucial to distinguish running styles from each other.Aim: The stretch goal is to build a running style app, which is able to track and display the user’s current running style by using accelerometry data, based on which advice can be given for a healthy and efficient running style with the help of gaming tools. To validate the approach, a gold standard with outdoor running acceleration data has to be created.Methods: The accelerometry data used by the smartphone app is gathered from the “actibelt”, an accelerometer included in a belt buckle. This sensor collects data close to the body COM in all three dimensions which is transferred to a smartphone via Bluetooth in real-time. The focus of this work is the validation of an acceleration based detection of different running styles, namely heel strikes, midfoot strikes and forefoot strikes. Features, which are able to clearly distinguish different running styles, have to be extracted out of the accelerometry data with machine learning techniques (SVM). Laboratory experiments have been conducted to analyze the actibelt data of three test persons performing heel, midfoot and forefoot strikes on a pressure sensitive treadmill with video control. As running apps are mainly used outdoors, the results had to be reproduced with outdoor running data. In an extreme ends approach four test persons with different running experience ranging from professional to occasional runners were asked to successively run on their heels, midfoot and forefoot, while accelerometry data was recorded and synchronized with mobile high speed video. The different running styles were performed on different substrates, with different shoes and speeds. Discussion/Conclusion: While significant differences in the accelerometry data of the running styles have been observed in the laboratory, those differences couldn’t be reproduced in outdoor environments. Characteristic peak patterns (Lieberman, nature 463, 531-535) could be reproduced in the laboratory but disappeared in outdoor running. The most distorting aspects are the harder and less comfortable surface and an irregular speed compared to treadmill running. Hence, for a reliable detection of the running style, the actibelt data may be complemented by further sensors, e.g. placed in the socks. A promising idea is to influence the stride frequency of runners at given speeds to improve the individual running style.

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Meta Products

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Motivation

Shoes

Injuries

Weather

“Develop an app that distinguishes individual running styles based on accelerometry data.”

Running experience

Speed

Substrate

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Motivation

Different running styles

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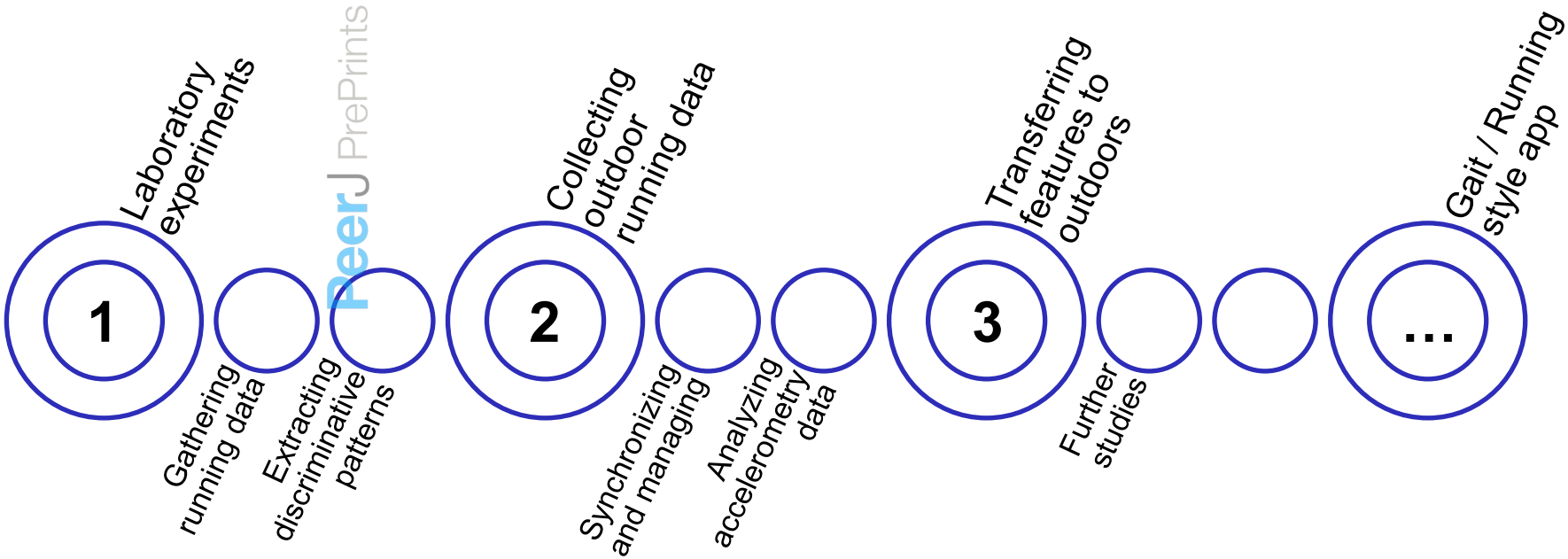
Developing a Running App



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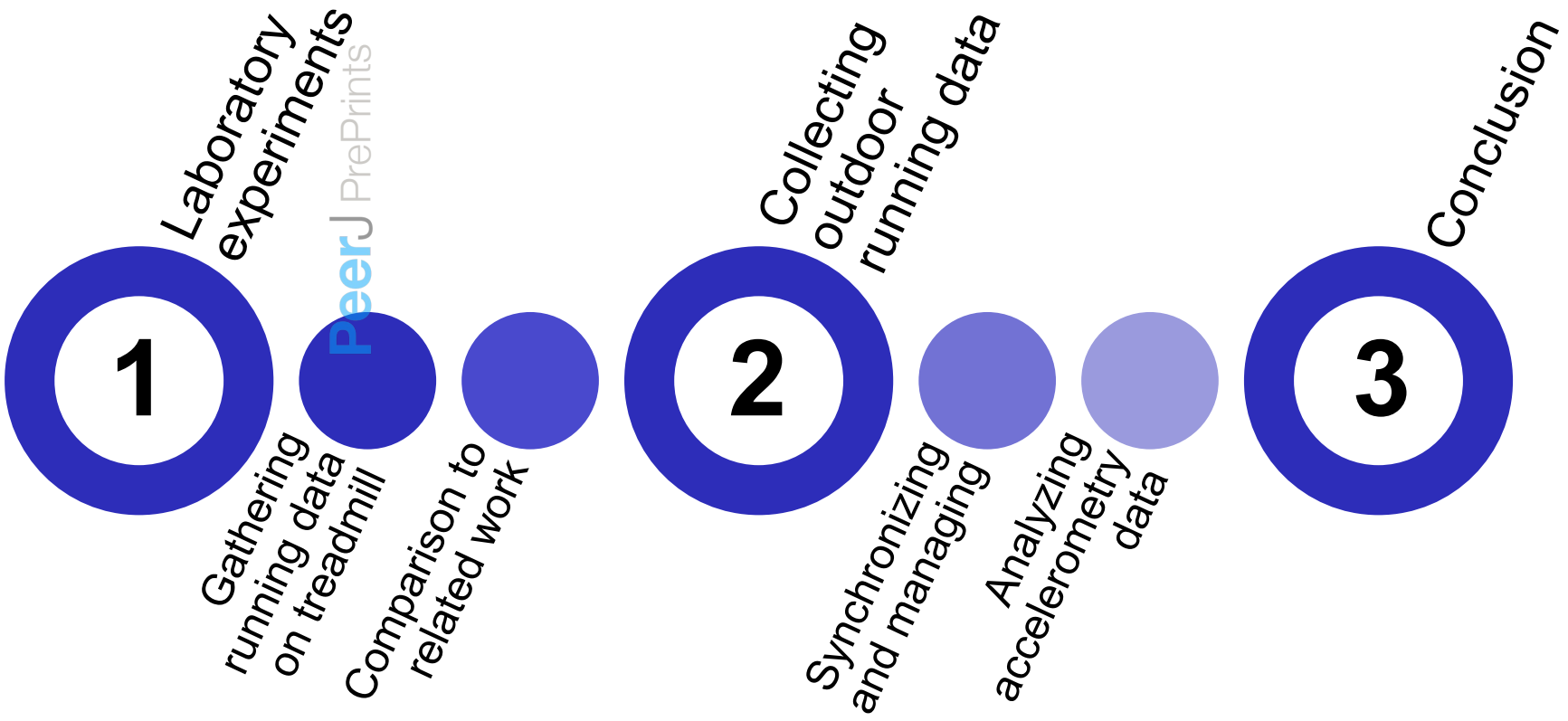

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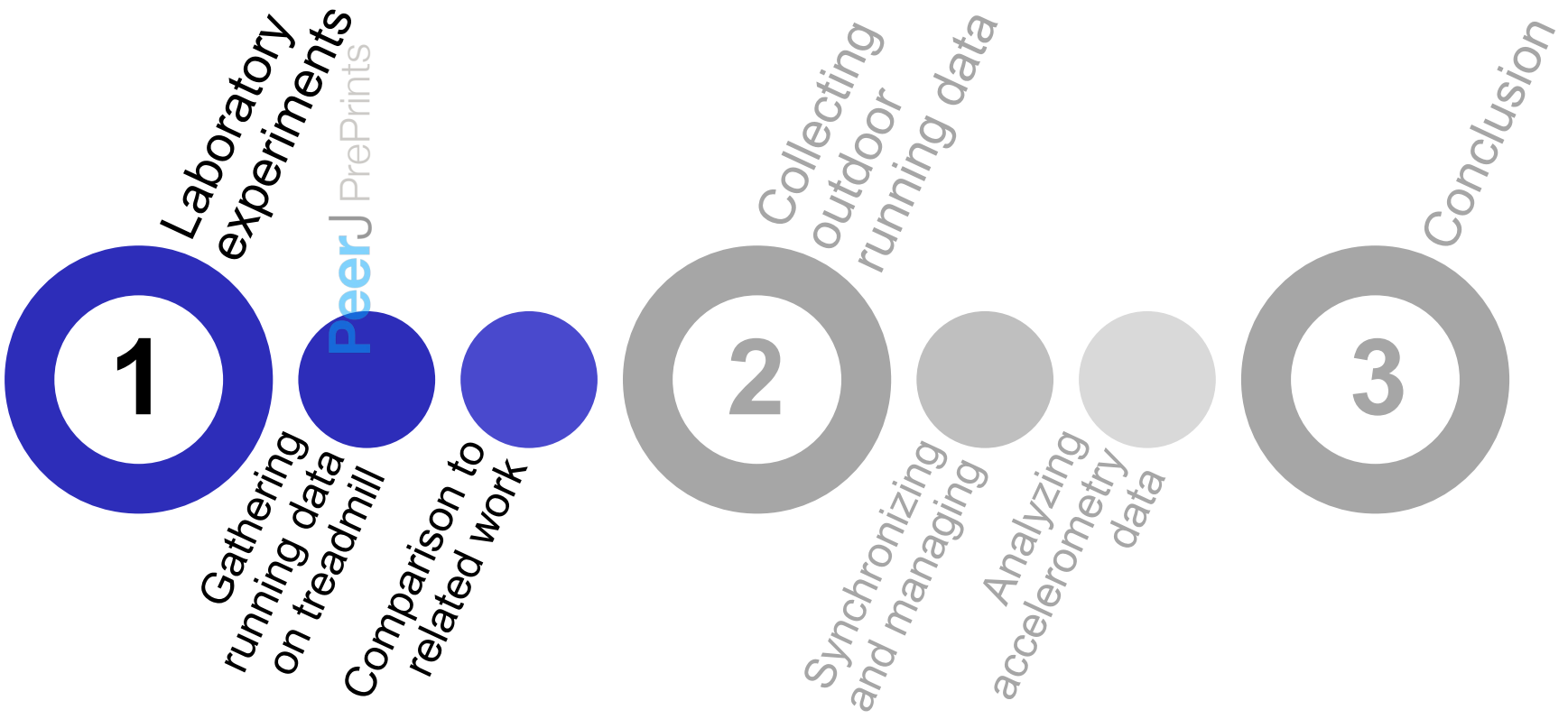

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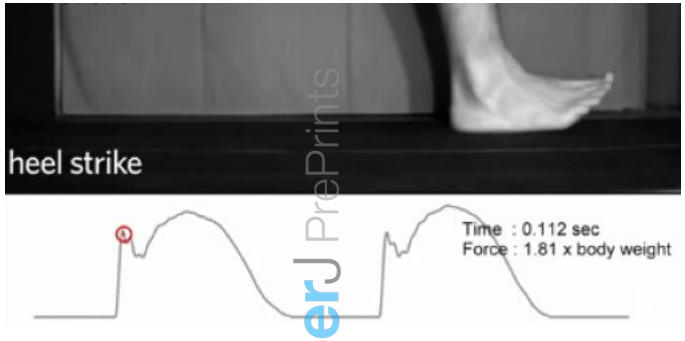
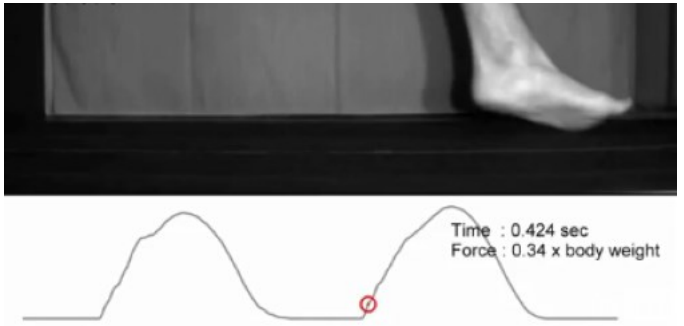
Laboratory Experiments

1

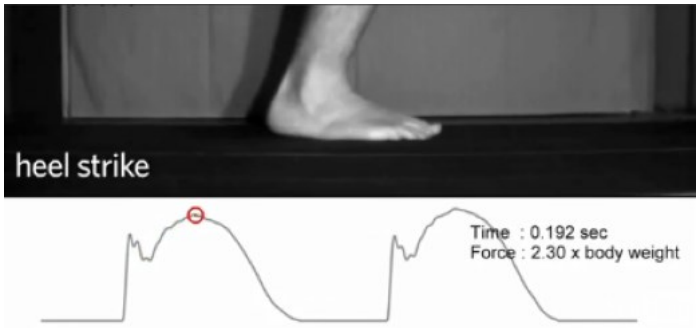
Laboratory Results[1]

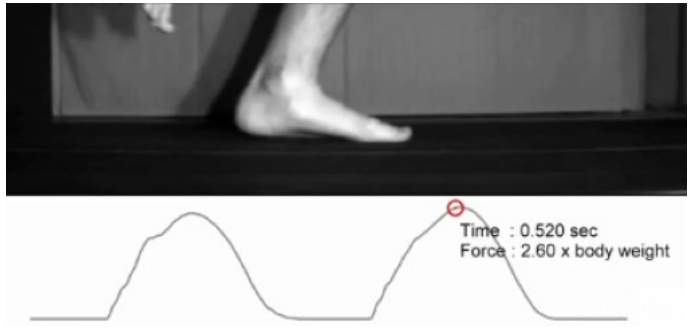




Heel strike

Forefoot strike





[1] D. Lieberman, *Foot strike patterns and collision forces in habitually barefoot versus shod runners*, Nature – Journal of Science, 2010.

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Laboratory Experiments

1 Comparing Measurement Methods

- Reproducing the results of [1] to get clear double peaks for heel strikes and a single peak for forefoot strikes

- Comparing the accelerometry data with pressure measurements on a treadmill

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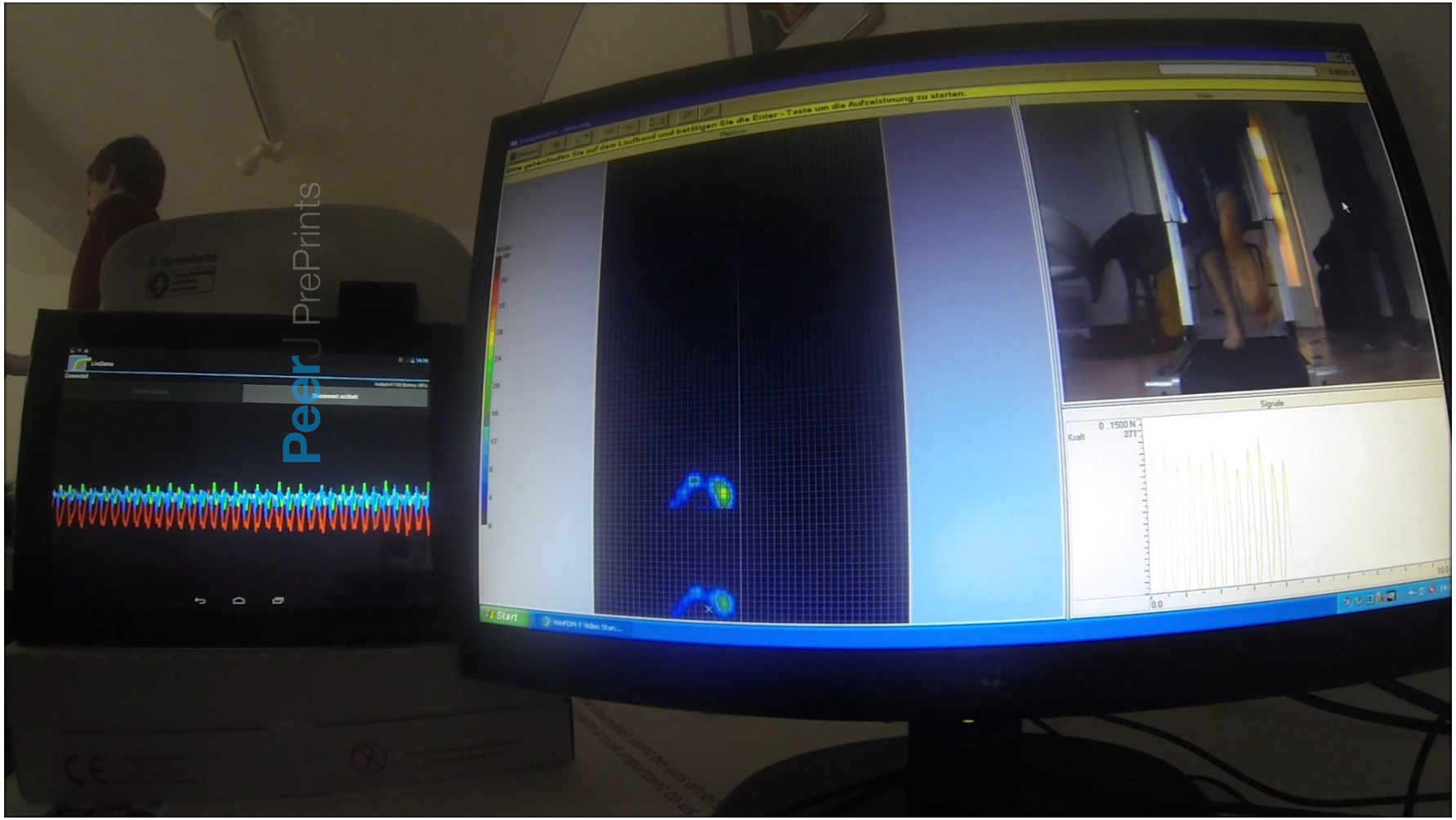
Collecting Data on a Treadmill



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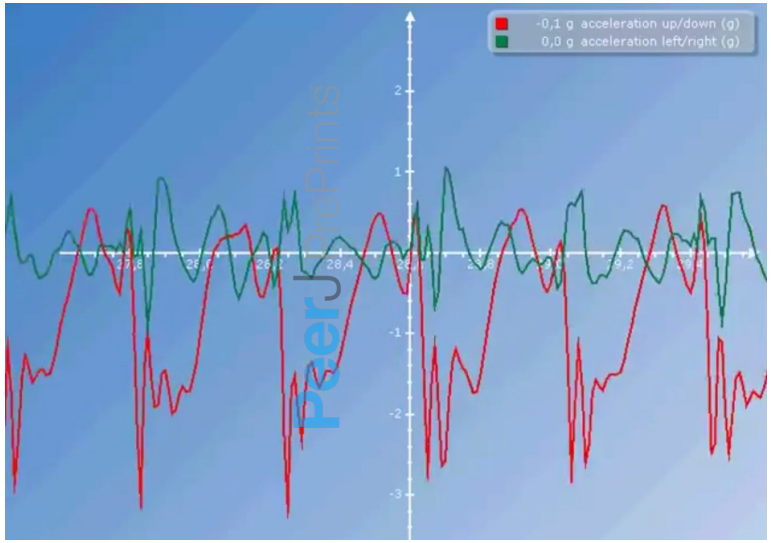
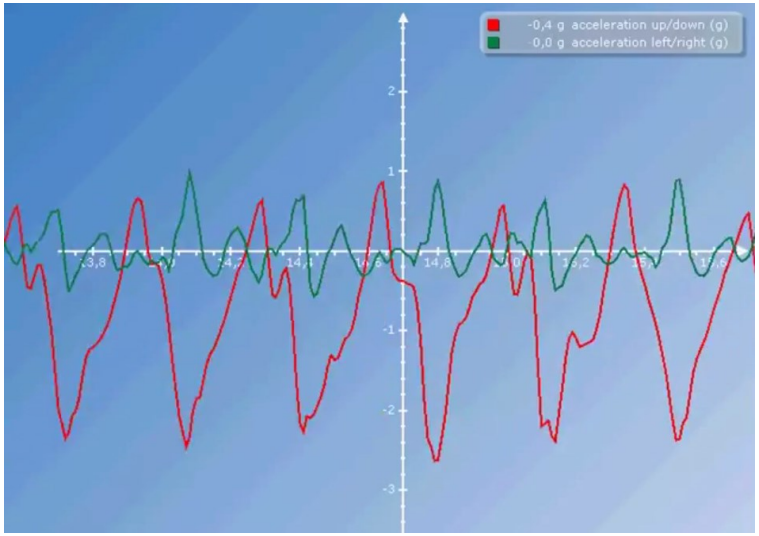
Collecting Data on a Treadmill

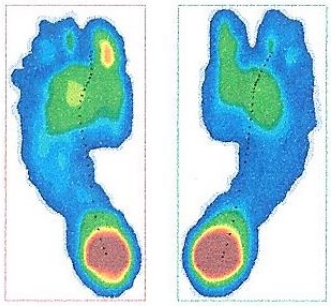
1

Pressure and Acceleration

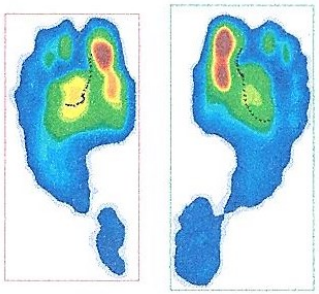




Heel strike



Forefoot strike



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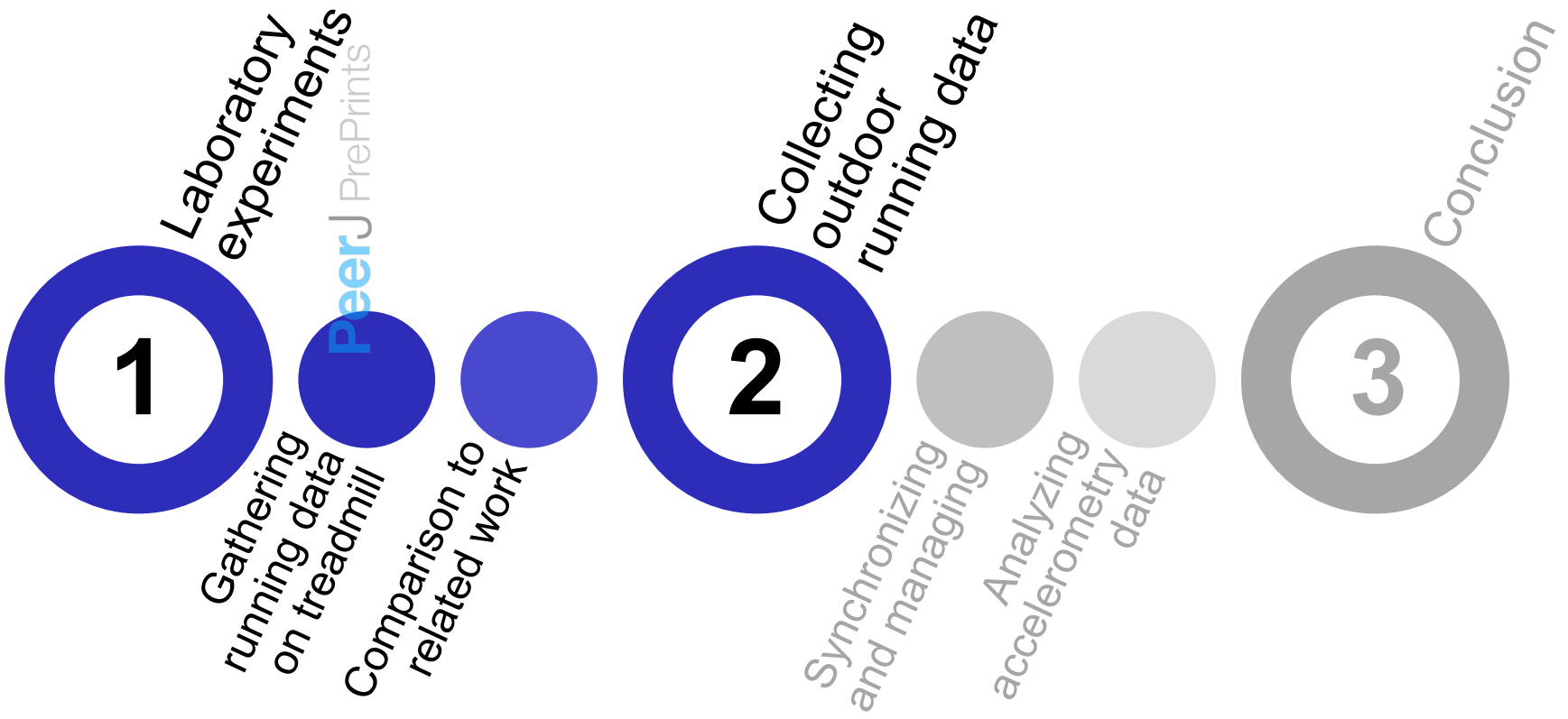

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Collecting Outdoor Running Data

2

- Professional
- Advanced
- After injury

- Trekking shoes
- Minimal footwear
- Running pads

- Street
- Grass
- Mountain path

- 10 km/h
- 15 km/h

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2

Examined Types of Shoes

Trekking Minimal Footwear Running Pads

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Collecting Outdoor Running Data

2

Recording Devices

- HD Videos with
  - Bicycle
  - Quadrocopter
- Acceleration with
  - Actibelt

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Collecting Outdoor Running Data

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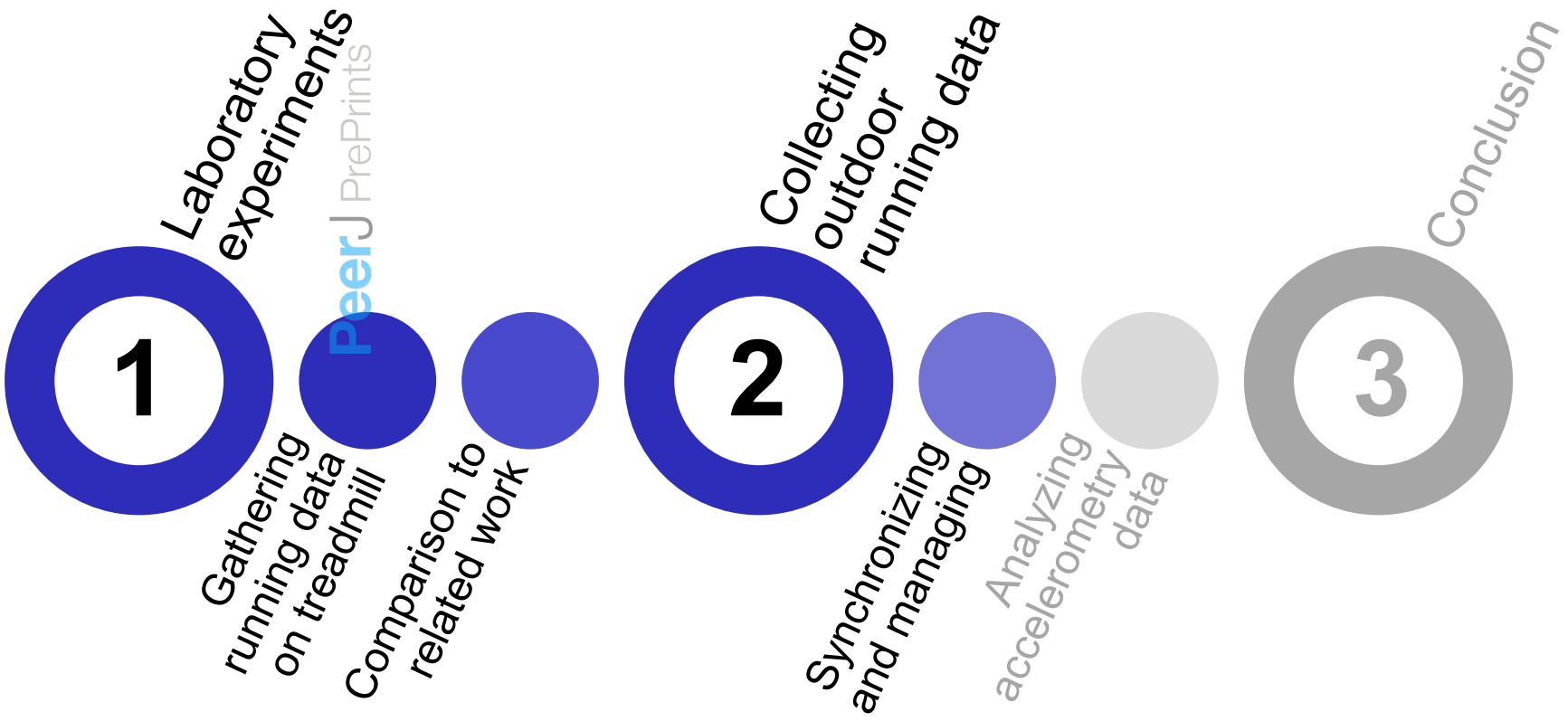

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2

Database

- In total about 150 running sequences with
  - Accelerometry data
  - Videos

- Synchronization creating a gold standard

- Tool for data management and analysis

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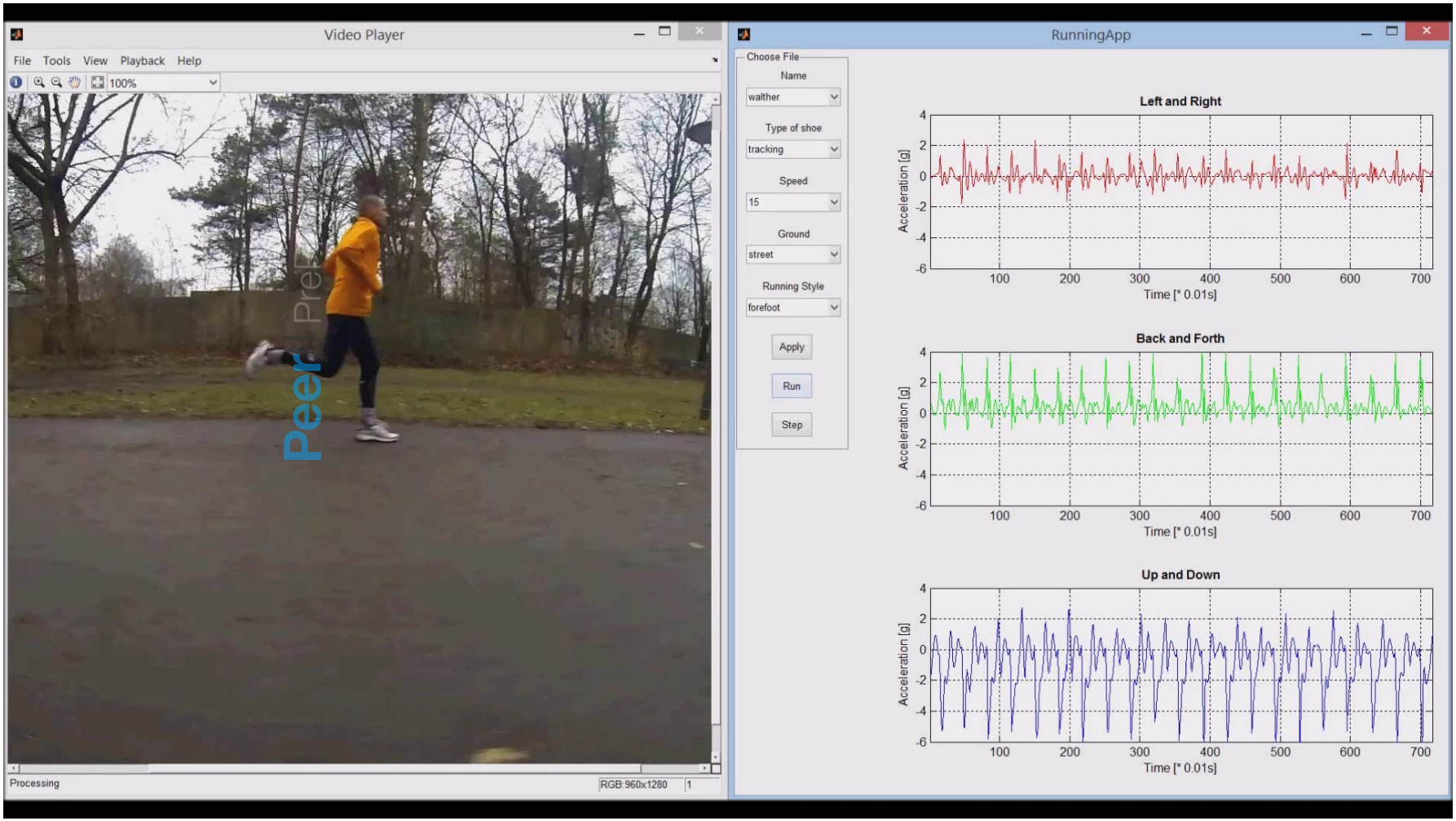
Synchronizing and Managing the Data



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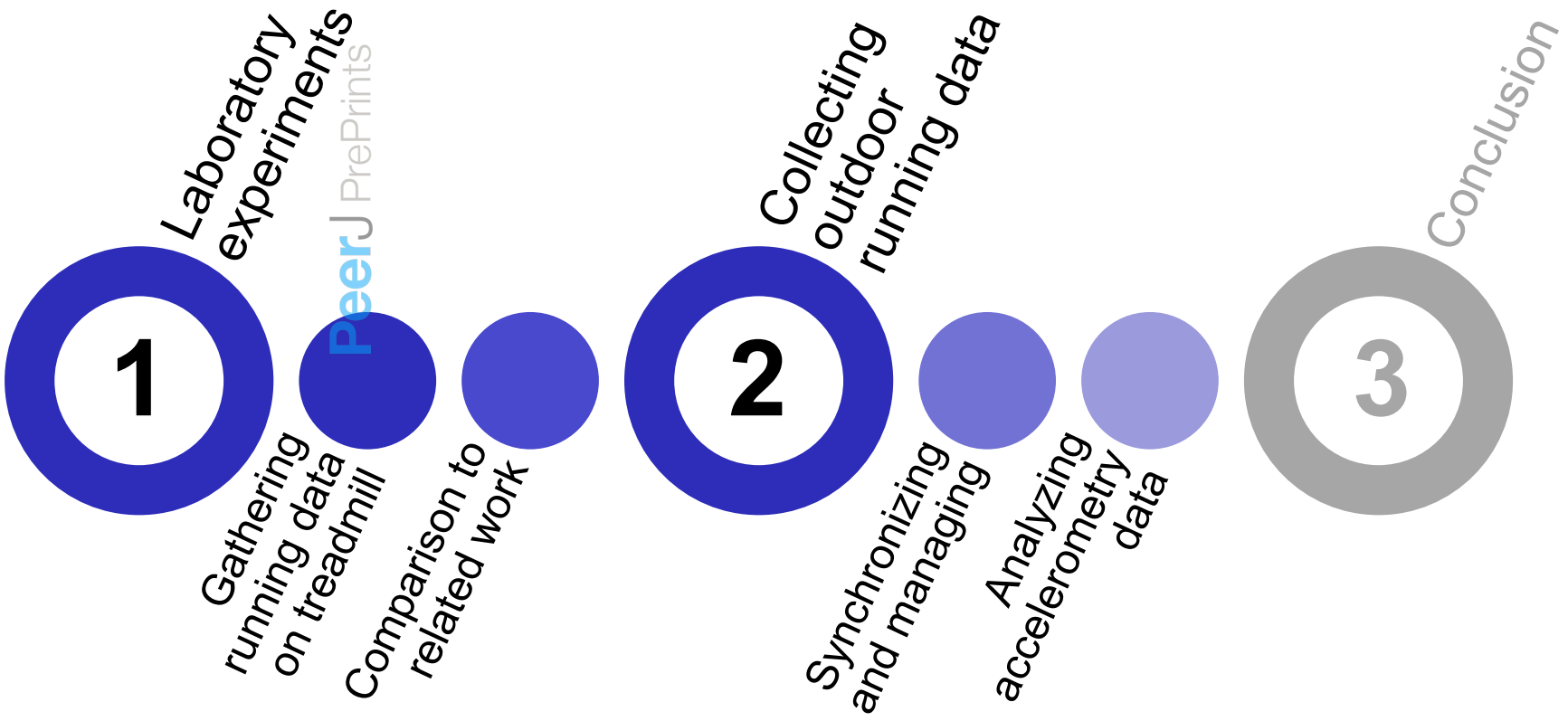

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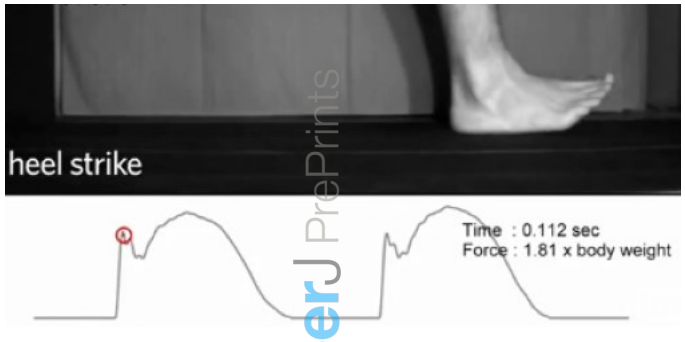
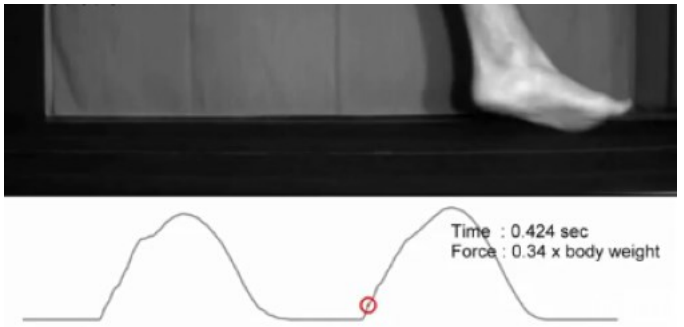
Analyzing Running Data

2

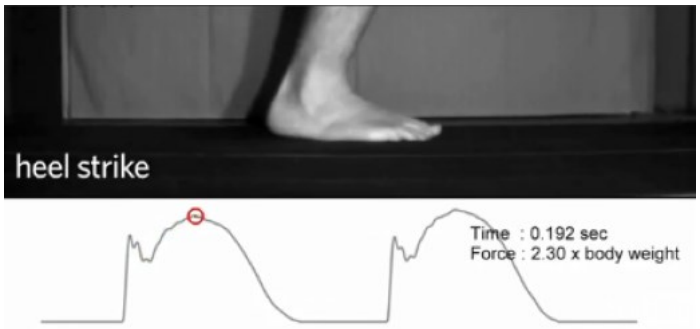
Laboratory Results[1]

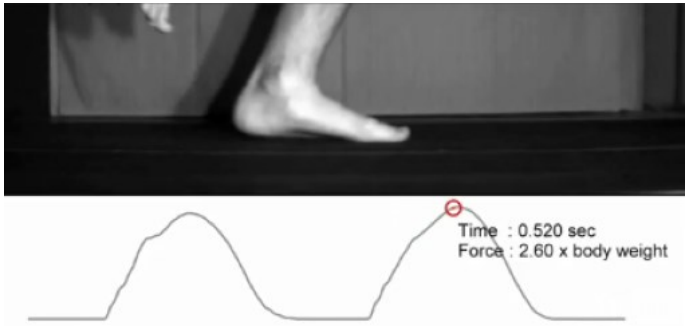




Heel Strike

Forefoot Strike





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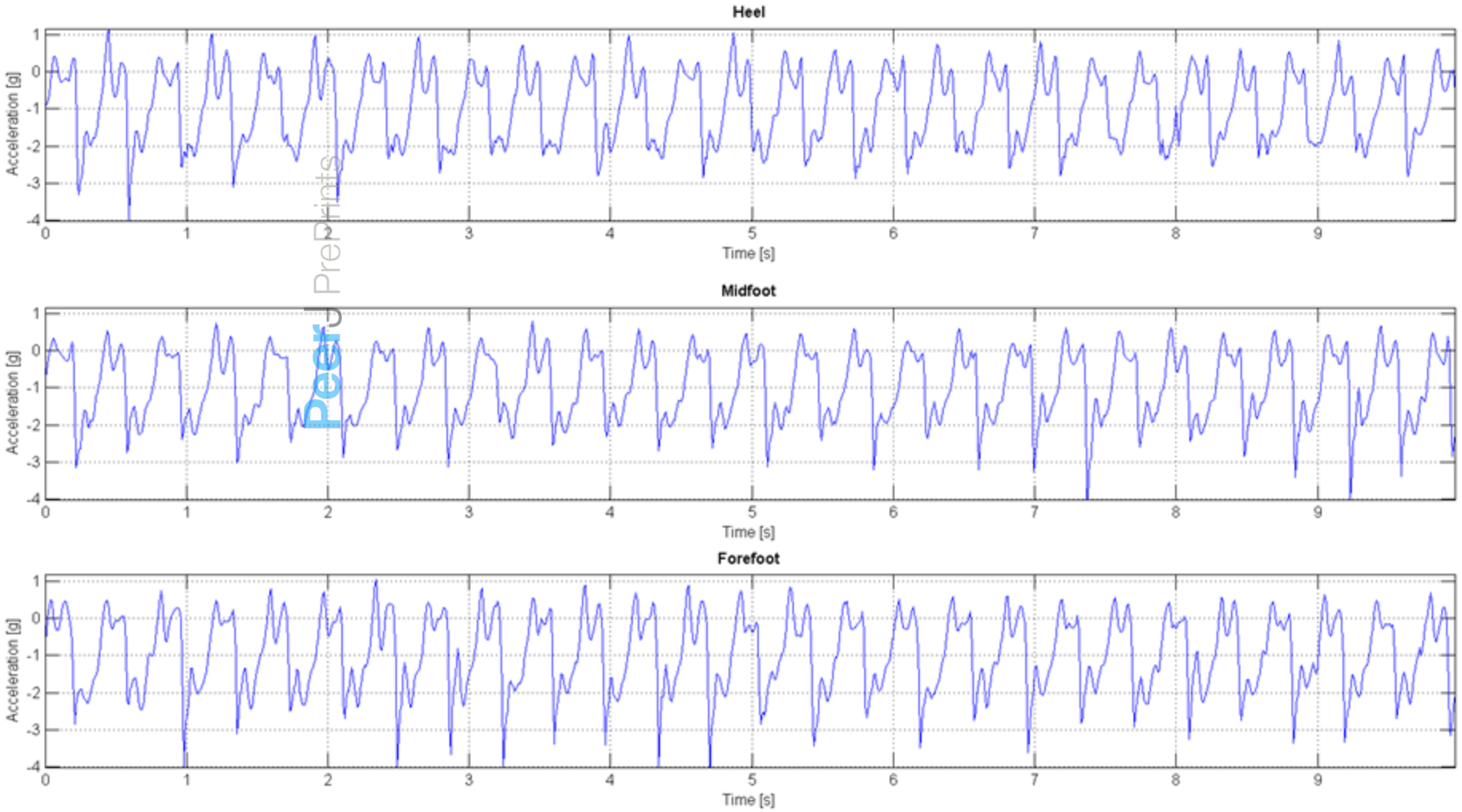
Analyzing Accelerometry Data



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2

Analyzing Features

- Considered features
  - Step width
  - Mean amplitude
  - Mean step
  - Standard deviation of steps
- Not discriminative enough to distinguish heel, midfoot or forefoot strikes (~70 % accuracy)

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Analyzing Accelerometry Data

2

Step Ratio

- The step ratio is slightly different for
  - Forefoot Strikes
  - Heel Strikes

- Heel Strikes performed with a higher frequency in ~75 % of all cases

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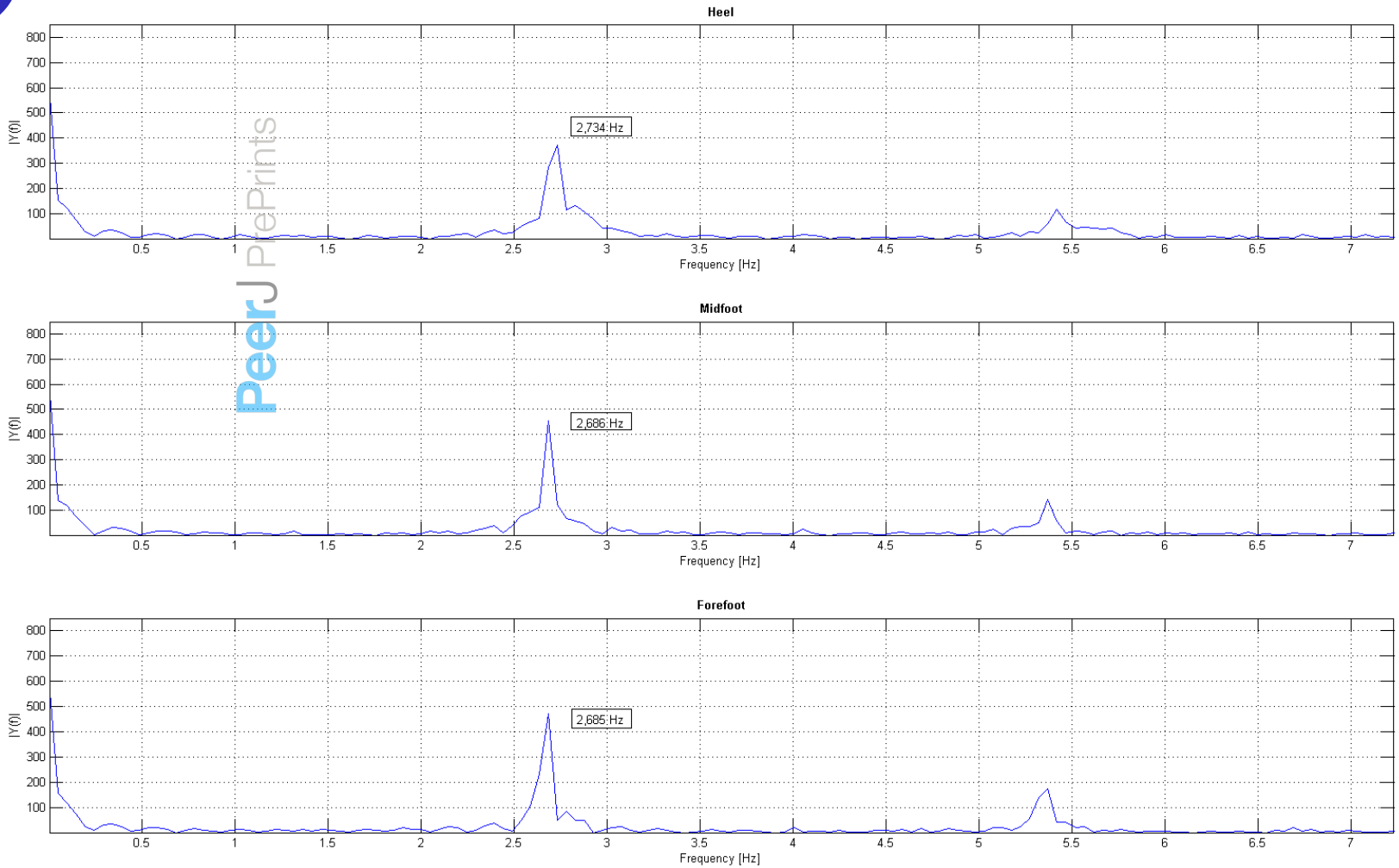
Analyzing Accelerometry Data

2

Fourier Transform



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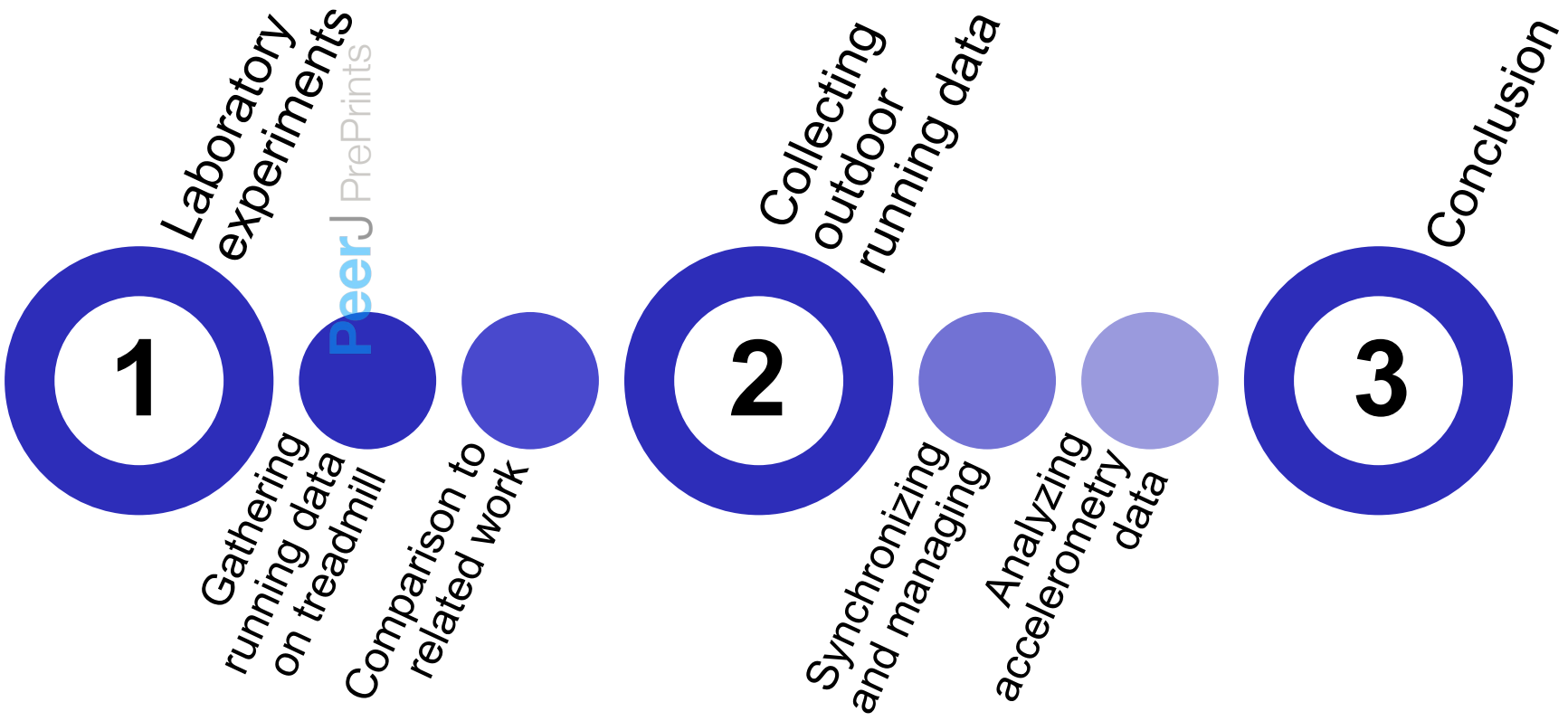

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Conclusion

3

Summary

- Accelerometry data coincides with pressure measurements
- Running style differences distinguishable with accelerometry data in the laboratory
- But laboratory results non-repeatable in outdoor environments

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3

Conclusion

- Running experiments should be conducted outdoors
- Better running style features necessary

Future Work

- Further focus on outdoor data
- Implementation of a gait/running style app

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