3D-Head acceleration used for lameness detection in dairy cows

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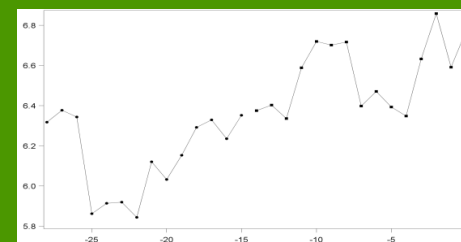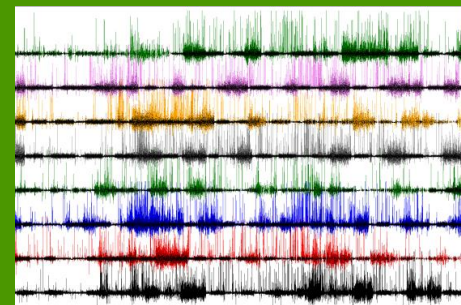[2] TiDaTier und Daten GmbH, Westensee, Germany

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Lameness

– Health & welfare problem

– One of the most frequent and costly diseases (Kramer *et al.,* 2009)

$\rightarrow$ **Detection of lameness**

– Changed behaviour and movement patterns

• Compensatory head movement (Buchner *et al.,* 1996, 2003)

• Lower activity level (Mazriere *et al.,* 2006; Alsaaod *et al.,* 2012)

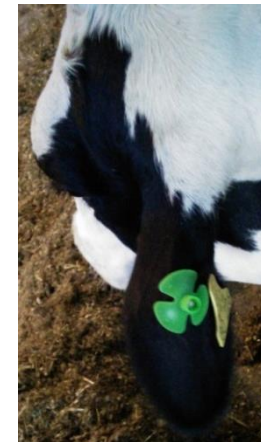$\rightarrow$ **Different perspective of acceleration data with acceleration sensors attached to the ear**

Aim

Using differences in 3D-Head acceleration data for the detection of lamenesses in dairy cows
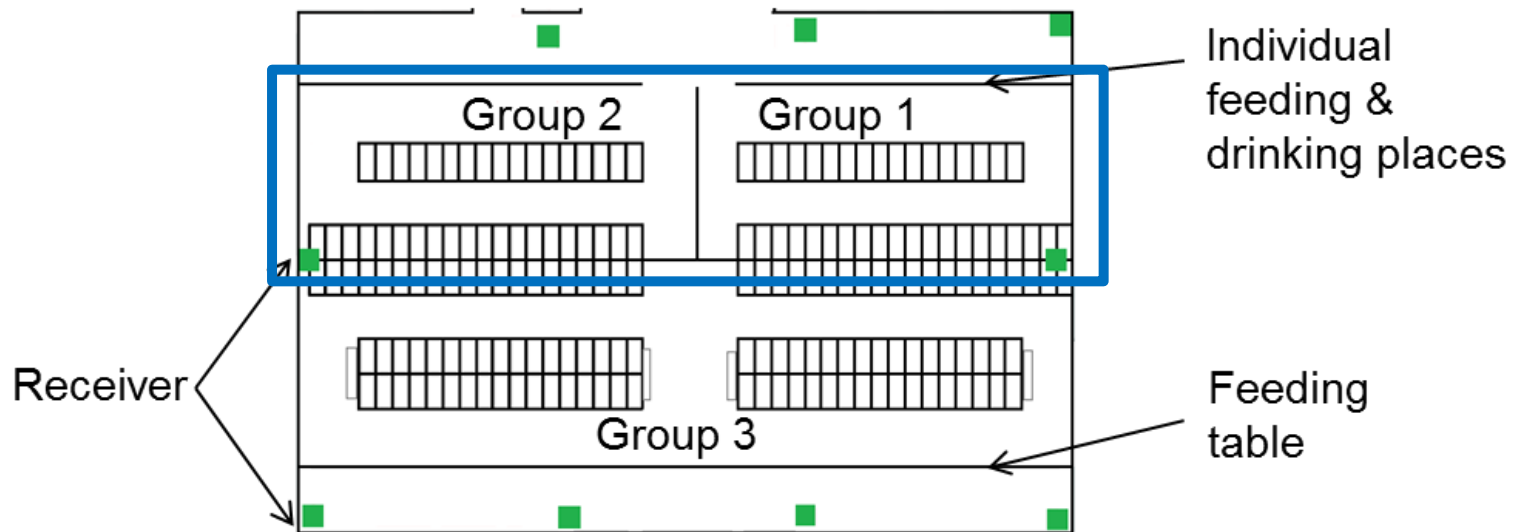
Eartag (MKW electronics)

– Location (ToA)

– Acceleration

• 3D Acceleration (x, y, z)

• Total acceleration:

$$a_t = \sqrt{a_x^2 + a_y^2 + a_z^2}$$

• 10 Hz and 1 Hz

– Losses of eartags

• 15 % eartags (1. batch)

• 0 % eartags (2. batch)

Research farm Futterkamp

Animals

- 70 Holstein Friesian cows
- 13 months (01.02.2014 – 28.02.2015)

Locomotion scoring (Sprecher *et al.*, 1997)

1 Normal
Stands and walks with a level back

2 Mildly Lame
Stands with a flat back
Walks with arched back
Gait slightly abnormal

Non Lame

3 Moderately Lame
Stands and walks with arched back
Short strikes with one or more legs

4 Lame
Stands and walks with arched back
Favoring one ore more legs

Lame

5 Severely Lame
Pronounced arched back
Reluctant to move and avoidance of affected limb
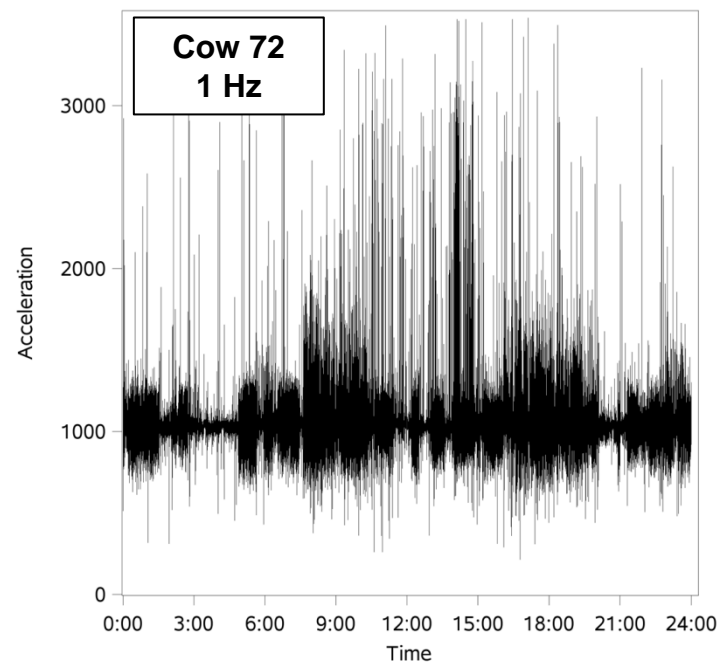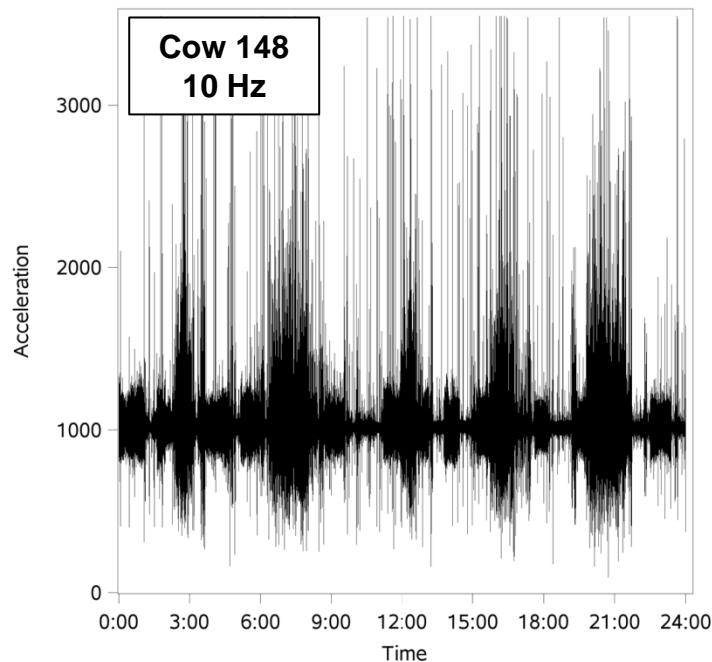
Datasets

- 10 Hz (864,000 values / cow & day)

- 1 Hz (86,400 values / cow & day)

- 10 to 1 Hz (1 Hz dataset + 10 Hz dataset)

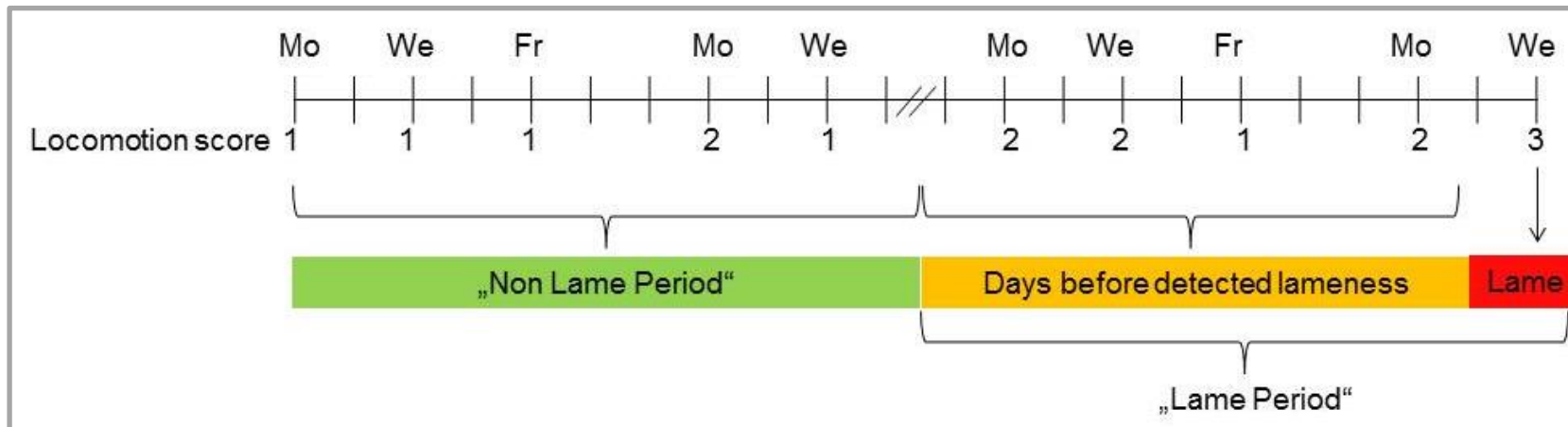**Acceleration data of one day and cow – 10 Hz and 1 Hz**

Definition of "Non Lame Period" and "Lame Period"

- **"Non Lame Period"**
  - 11 days
  - Reference data set
- **"Lame Period"**
  - 11, 9, 7, 5 or 3 days

Daily values of acceleration data per cow

- Mean
- Variance
- Standard deviation
- Square sum
- Skewness
- Kurtosis
- Percentile 25
- Percentile 75
- p-variation
  - 1st, 2nd or 3rd power of the difference between serial acceleration data

Analyses of variance

- **Fixed effects**
  - Phase of lactation (1-7)
    nested in number of lactation (1 & 2, 3, 4)
  - Period ("Non Lame Period" and "Lame Period")
- **Random effect:** Animal

Datasets			
Data frequency	**Number of animals**	**Number of lamenesses**	**Number of days**
10 Hz	10	17	337
1 Hz	5	6	128
10 to 1 Hz	15	23	467

Significance of "Lame Period" on the parameters

Dataset	Parameter	Length of Period				
		11	9	7	5	3
1 Hz	Mean				■	
	Standard deviation					
	Variance					
	Square sum	■	■	■		
	Skewness	■	■	■	■	■ ✔
	Kurtosis	■	■	■	■	■ ✔
	Percentile 25	■	■	■	■	■ ✔
	Percentile 75	■				
	1st p-variation	■	■	■		
	2nd p-variation					
	3rd p-variation					

Significance levels:

■	p > 0.05
■	p ≤ 0.05
■	p ≤ 0.01

Significance of "Lame Period" on the parameters

Dataset	Parameter	Length of Period					
		11	9	7	5	3	
10 to 1Hz	Mean						
	Standard deviation						✔
	Variance						
	Square sum						
	Skewness						✔
	Kurtosis						✔
	Percentile 25						✔
	Percentile 75						
	1st p-variation						✔
	2nd p-variation						
	3rd p-variation						

Significance levels:

	p > 0.05
	p ≤ 0.05
	p ≤ 0.01

Significance of "Lame Period" on the parameters

| Dataset	Parameter	Length of Period					
		11	9	7	5	3	
10 Hz	Mean						
	Standard deviation	p ≤ 0.05	p ≤ 0.01	p ≤ 0.01	p ≤ 0.01	p ≤ 0.05	✔
	Variance		p ≤ 0.05	p ≤ 0.01	p ≤ 0.01		
	Square sum			p ≤ 0.01	p ≤ 0.01		
	Skewness						
	Kurtosis	p ≤ 0.01	p ≤ 0.01	p ≤ 0.01	p ≤ 0.01	p ≤ 0.01	✔
	Percentile 25	p ≤ 0.01	p ≤ 0.01	p ≤ 0.01	p ≤ 0.05	p ≤ 0.05	✔
	Percentile 75						
	1st p-variation			p ≤ 0.01	p ≤ 0.01	p ≤ 0.01	
	2nd p-variation	p ≤ 0.05	p ≤ 0.05	p ≤ 0.01	p ≤ 0.01	p ≤ 0.01	✔
	3rd p-variation	p ≤ 0.05	p ≤ 0.05	p ≤ 0.01	p ≤ 0.01	p ≤ 0.01	✔

Significance levels:
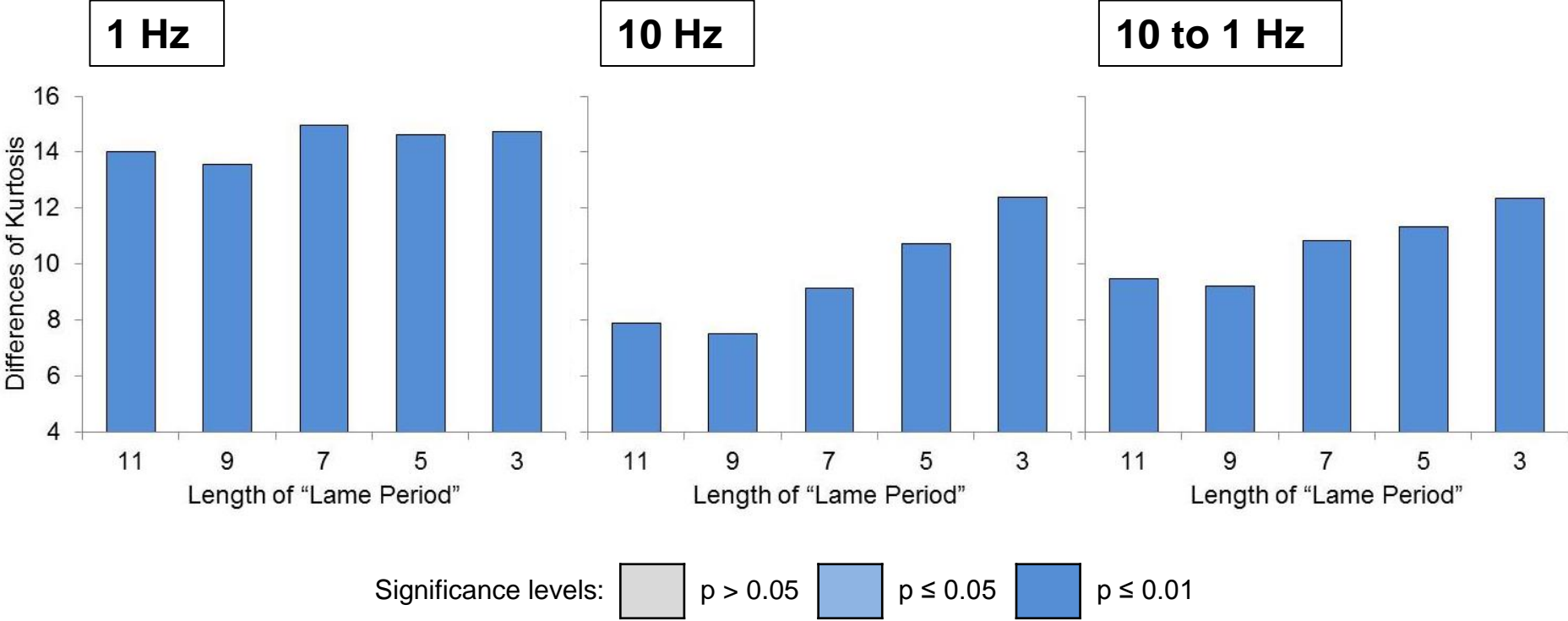
- p > 0.05
- p ≤ 0.05
- p ≤ 0.01

Results

Acceleration data of one day and cow (10 Hz) – Non lame & Lame
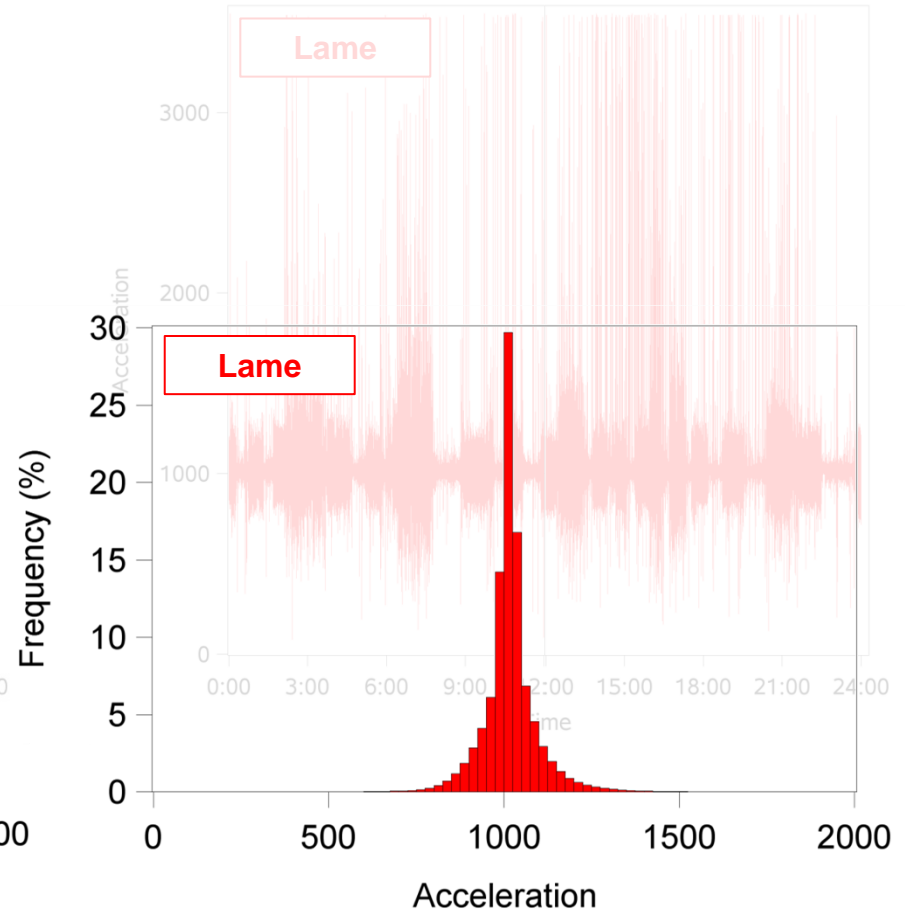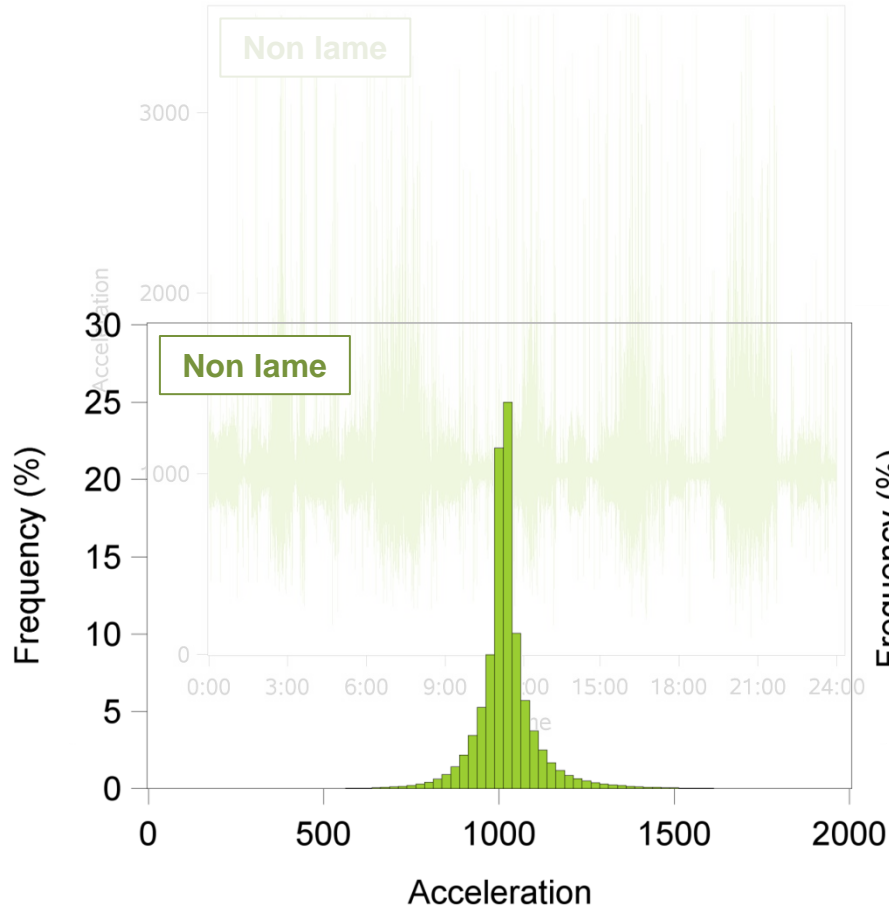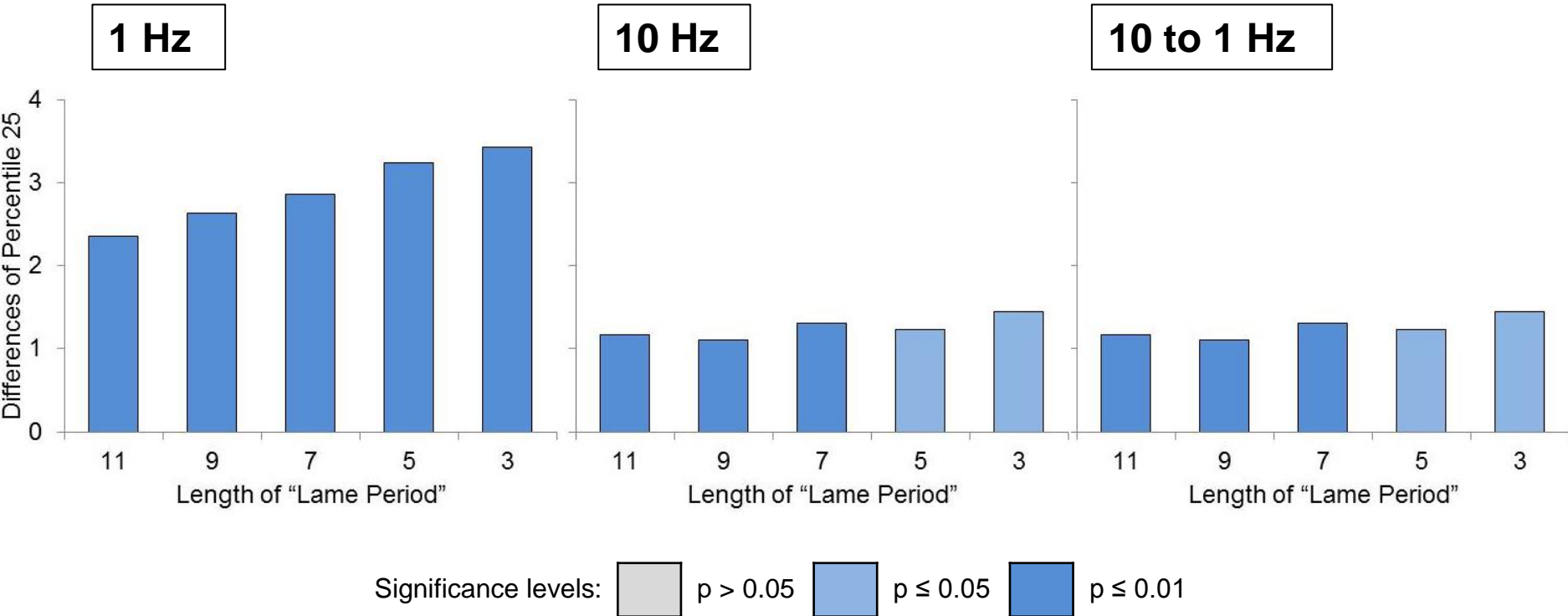
Results

Differences between LS-Means of Kurtosis of
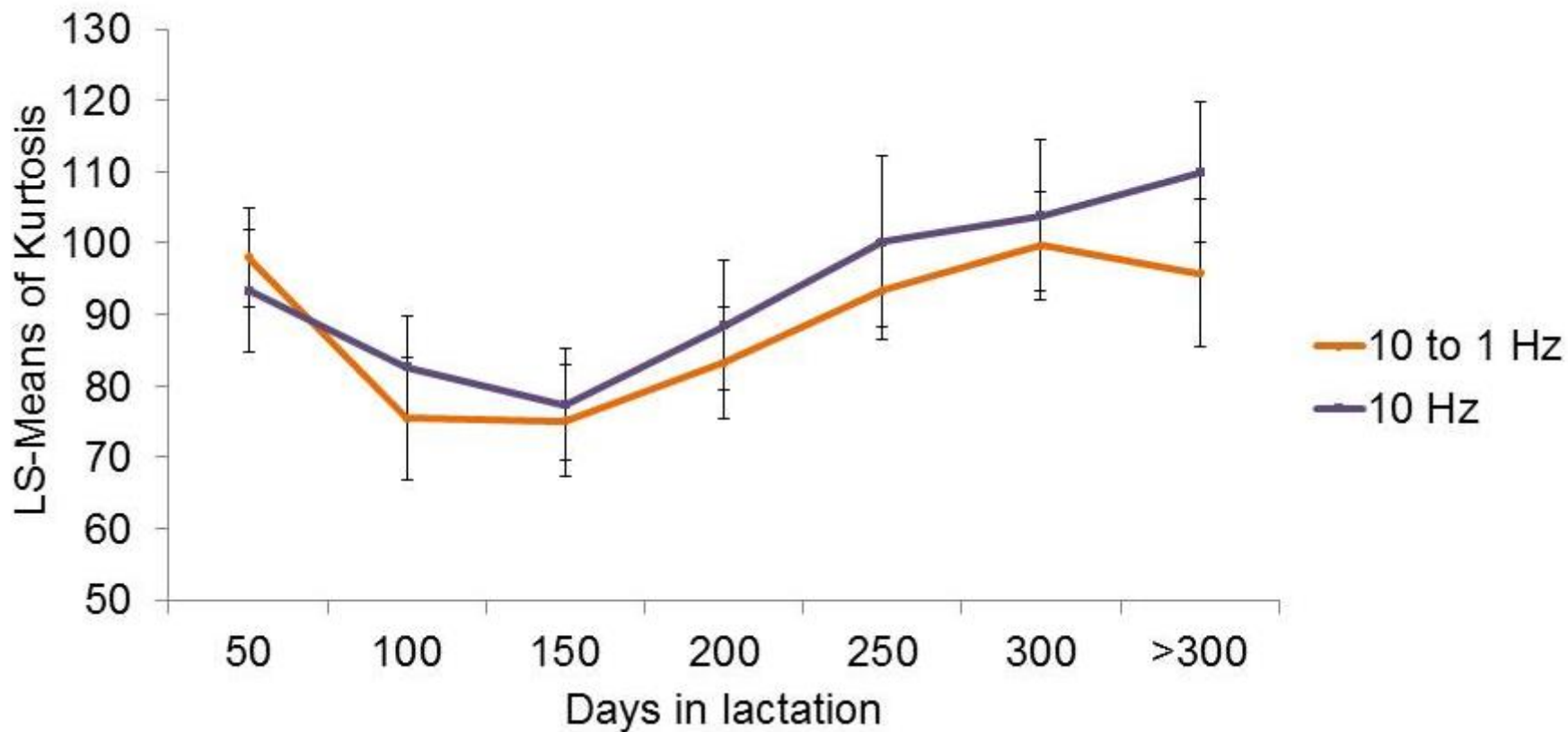"Non Lame Period" and "Lame Period"

Results

Differences between LS-Means of Percentile 25 of "Non Lame Period" and "Lame Period"

Results

LS-Means and standard error of Kurtosis during lactation

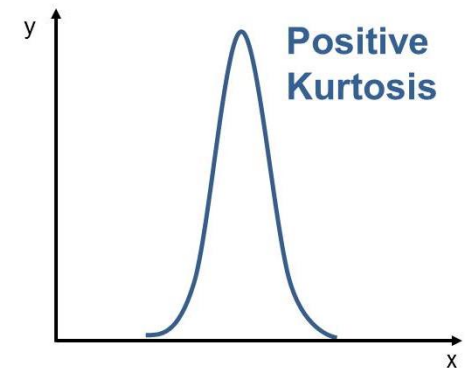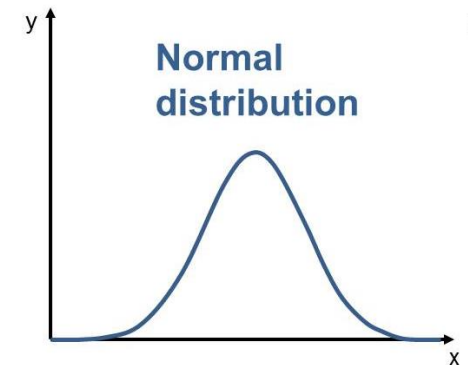**No significant differences between "Non Lame Period" and "Lame Period" for**

– **Location parameters**

$\rightarrow$ No shift of distribution on the x-axis

– **1 Hz dataset** has less significant values

$\rightarrow$ Small dataset and missing values

**Significant differences between
"Non Lame Period" and "Lame Period" for**

- **Kurtosis and Percentile 25**
  - → Change of data distribution

  - → Increase of slower acceleration values
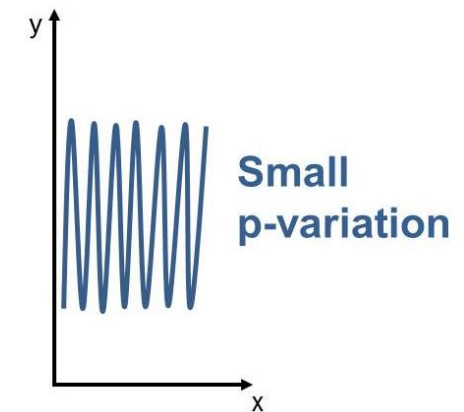 - → Activity level decreases

**Significant differences between
"Non Lame Period" and "Lame Period" for**

   –   **Kurtosis and Percentile 25**

     → Change of data distribution

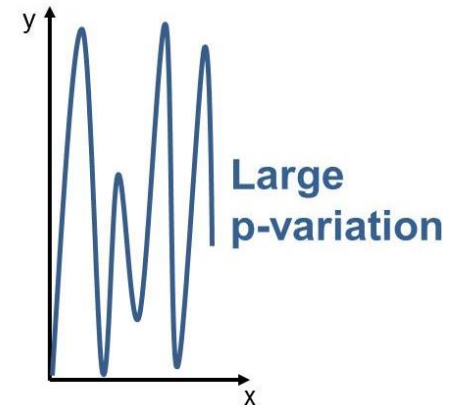   → Increase of slower acceleration values

     → Activity level decreases

     → No relevant head movement:
Smaller p-variation means more
homogeneous amplitudes

Large p-variation

Small p-variation

Distribution of acceleration data (e.g. Percentile 25, Kurtosis) can be used as an indicator for lameness

But: Each cow is different

– Activity level
– Sensation of pain

Outlook

– Present results have to be tested on an individual basis
– Analyses of location data

Acknowledgments

Results

LS-Means and standard error of kurtosis