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# Impact of back supporting exoskeletons on kinematics and joint loading of the lower body during gait

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# Introduction

- Supporting effects during dynamic lifting and static holding have been reported for active and passive back supporting exoskeletons (de Looze et al. 2016, Glitsch et al. 2020)
  - The greatest support effects were observed for high loads (20 kg) and lifting below knee height (0.4 m)
    - Peak lumbar moment was reduced up to 20% (Glitsch et al. 2020)

- Since many physically demanding jobs require at least short walking distances, exoskeletons should not interfere with level walking

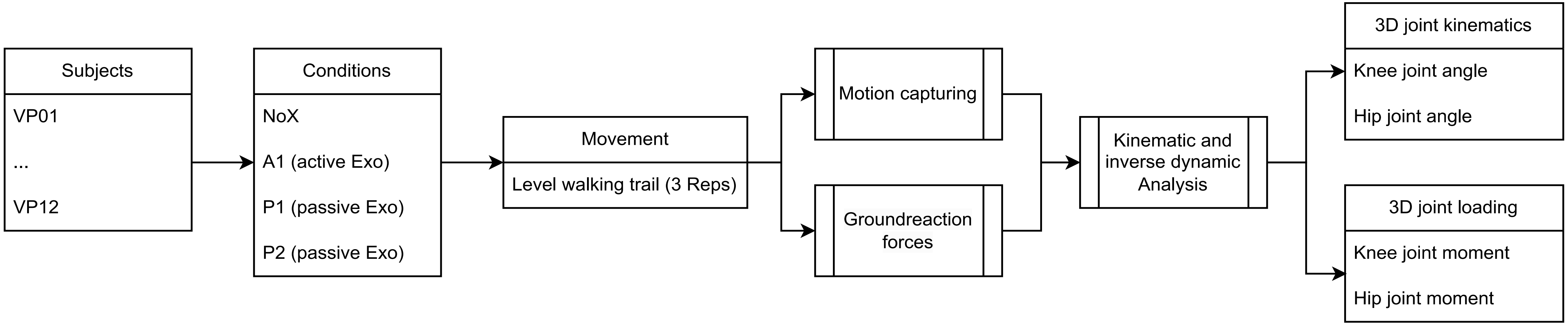
# Research Question

Do joint **kinematics** and joint **loading differ** between the **exoskeleton** (A1, P1, P2) and **non-exoskeleton** (NoX) conditions during level **walking**?

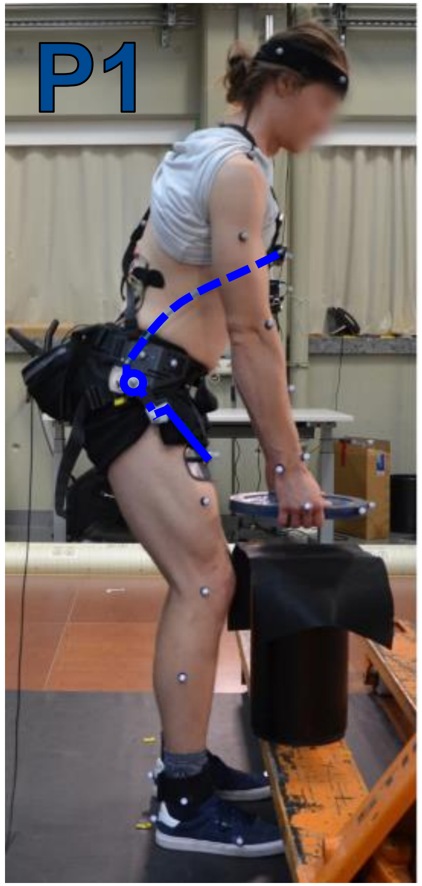
# Independent and dependent variables

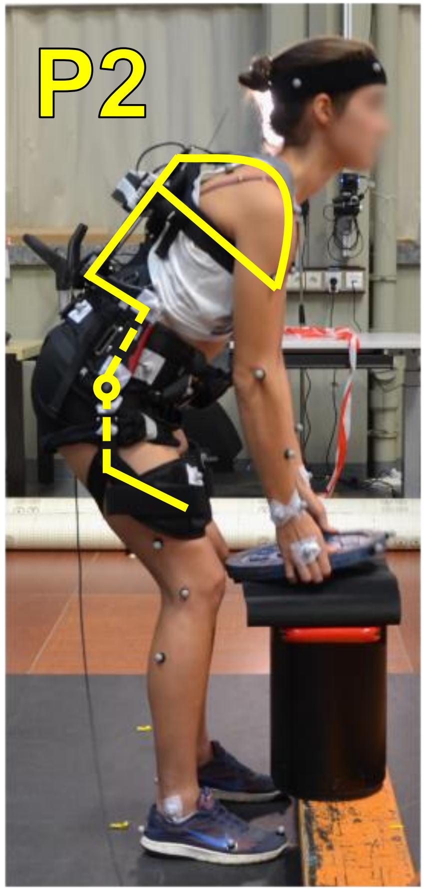
| Independent variables | Dependent variables |
| --- | --- |
| NoX (non Exo) | Kneeflexion angle |
| A1 (active Exo) | Kneeflexion moment |
| P1 (passive Exo) | Hipflexion angle |
| P2 (passive Exo) | Hipflexion moment |

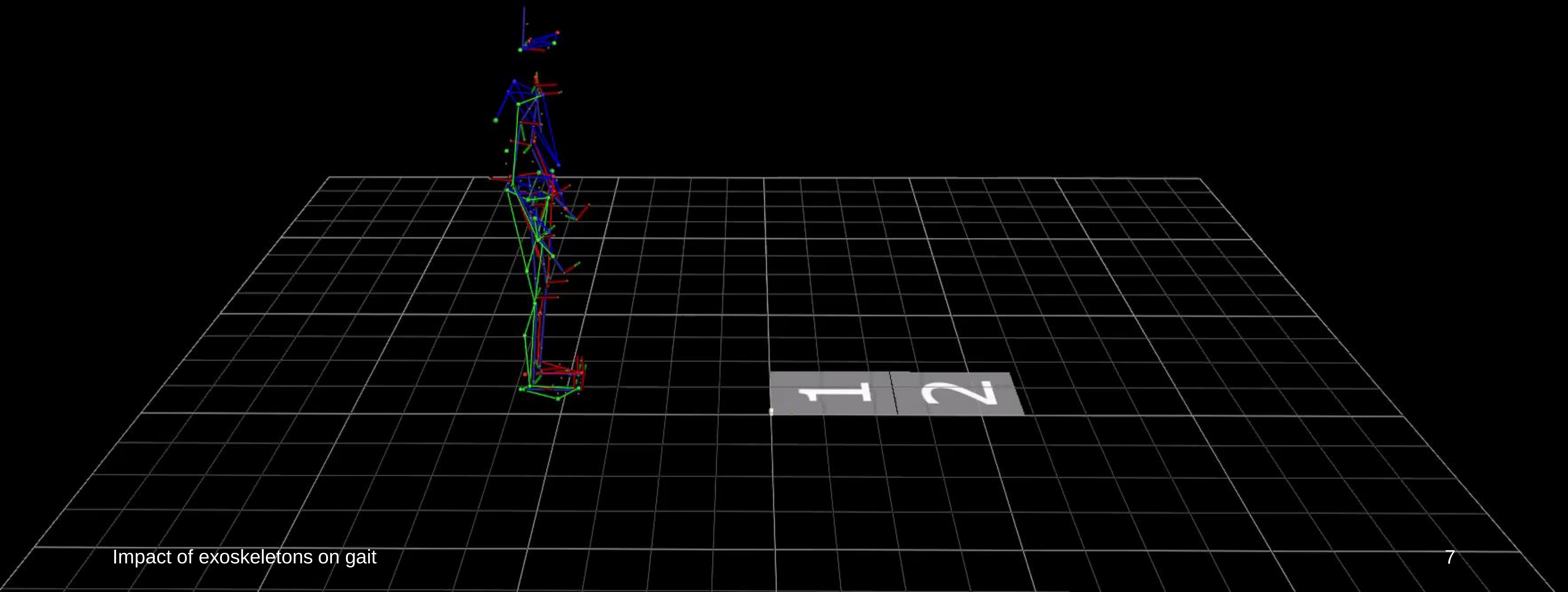
# Methods


Subjects
VP01
...
VP12
Conditions
NoX
A1 (active Exo)
P1 (passive Exo)
P2 (passive Exo)
Movement
Level walking trail (3 Reps)
Motion capturing
Groundreaction forces
Kinematic and inverse dynamic Analysis
3D joint kinematics
Knee joint angle
Hip joint angle
3D joint loading
Knee joint moment
Hip joint moment

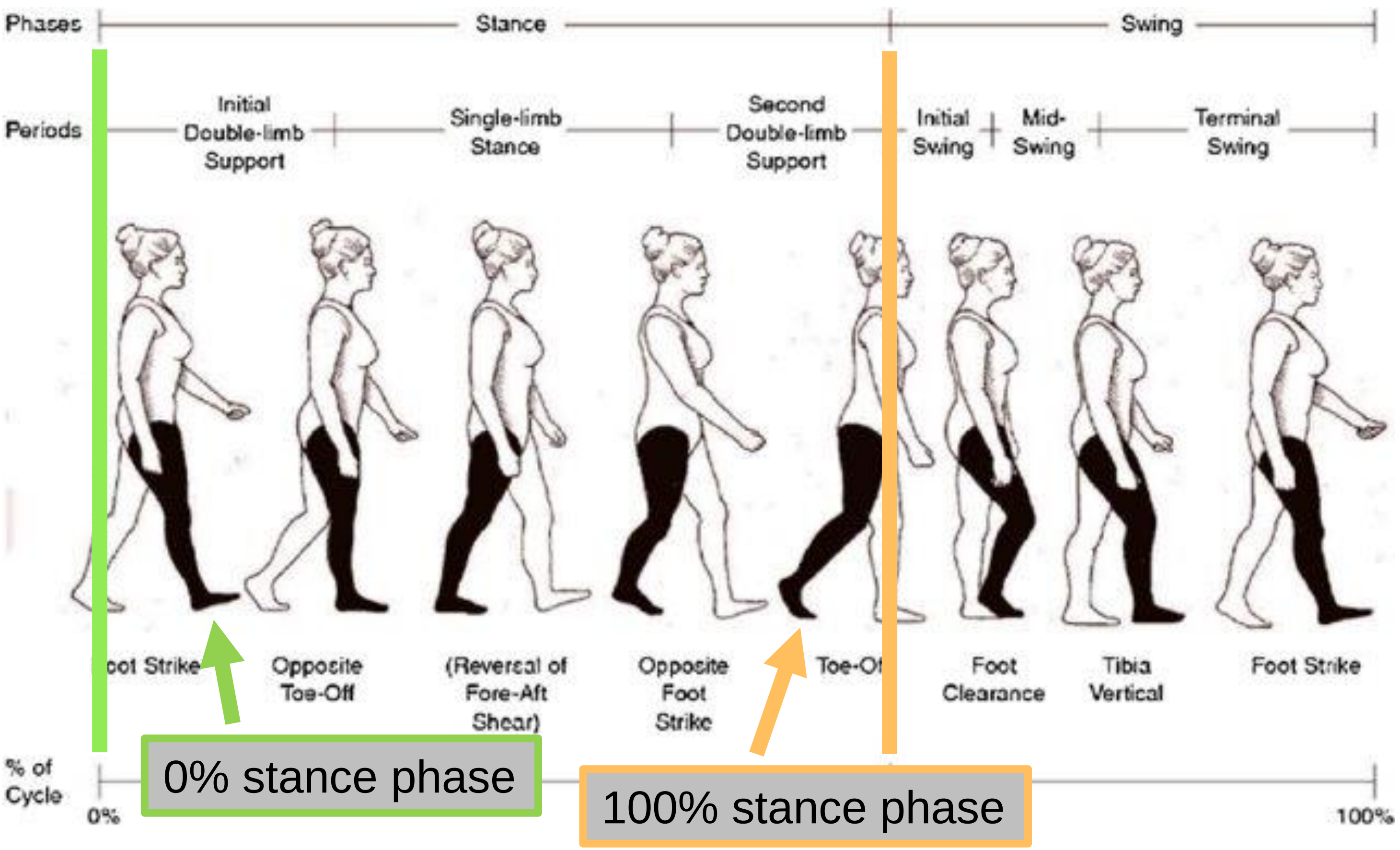
# Conditions (without NoX)

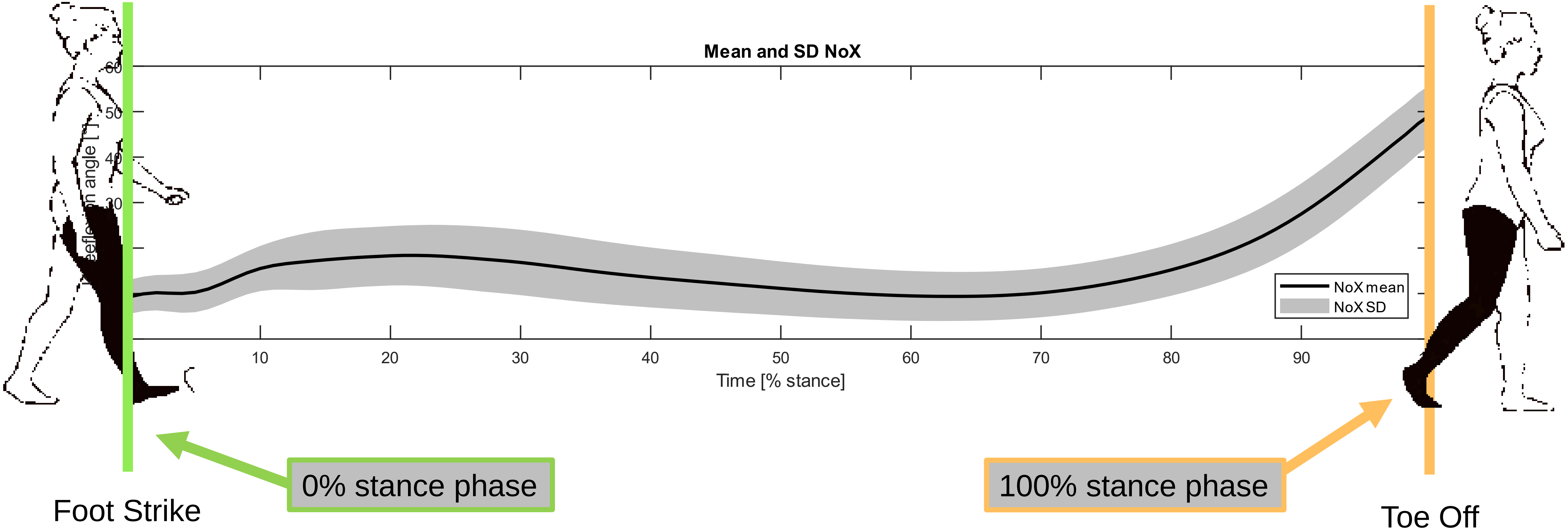




1
2

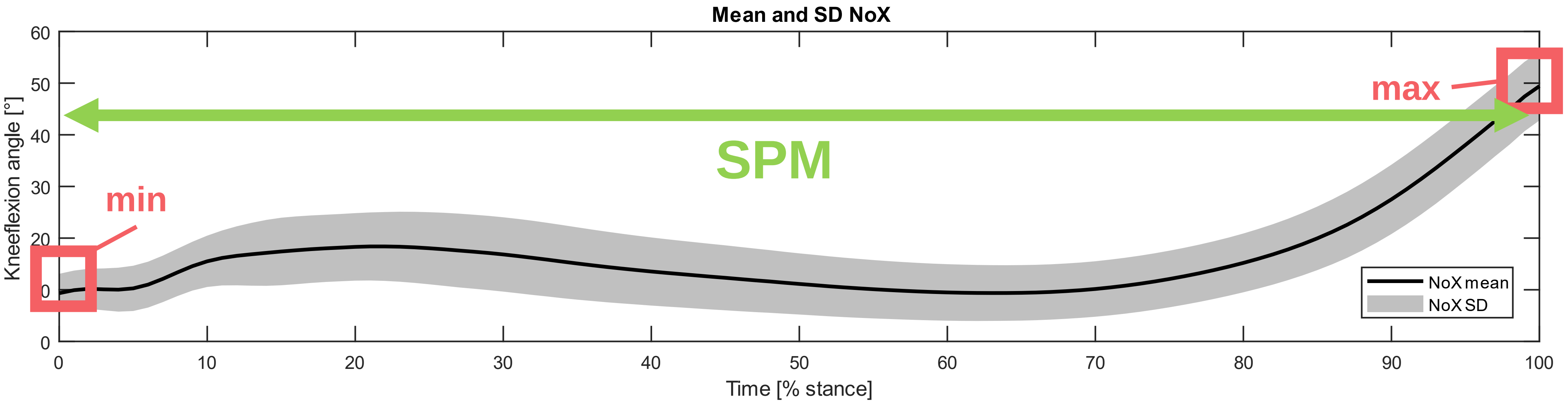
# Stance Phase



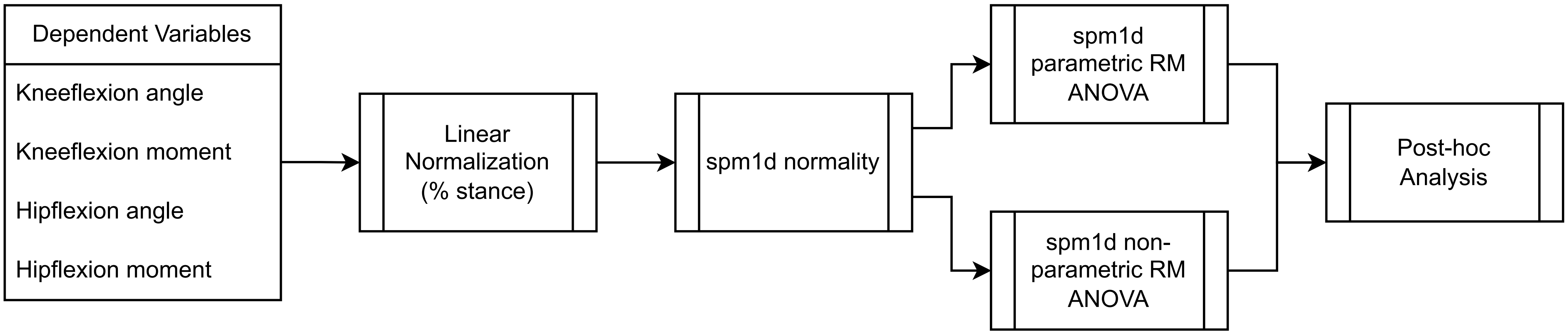
# Kneeflexion angle (stance phase)



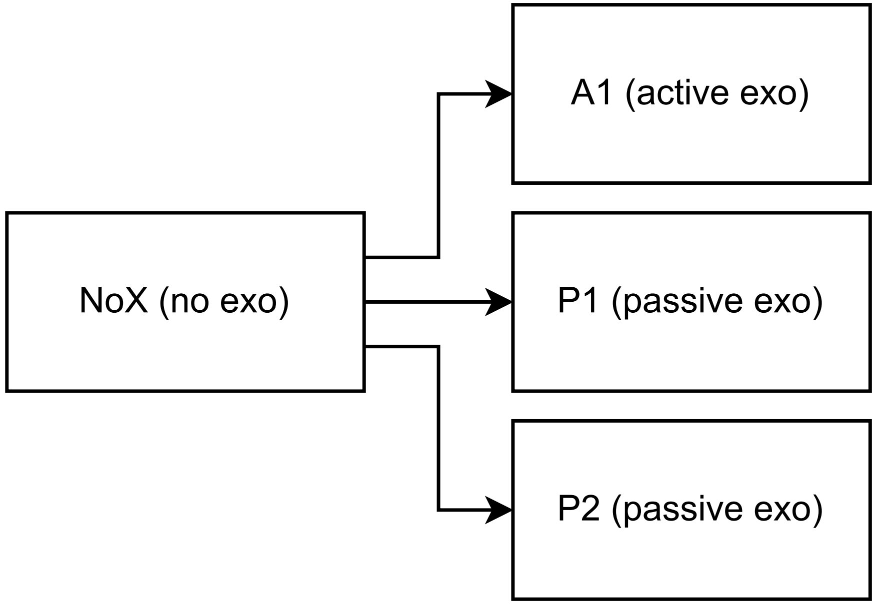
# Continous data analysis



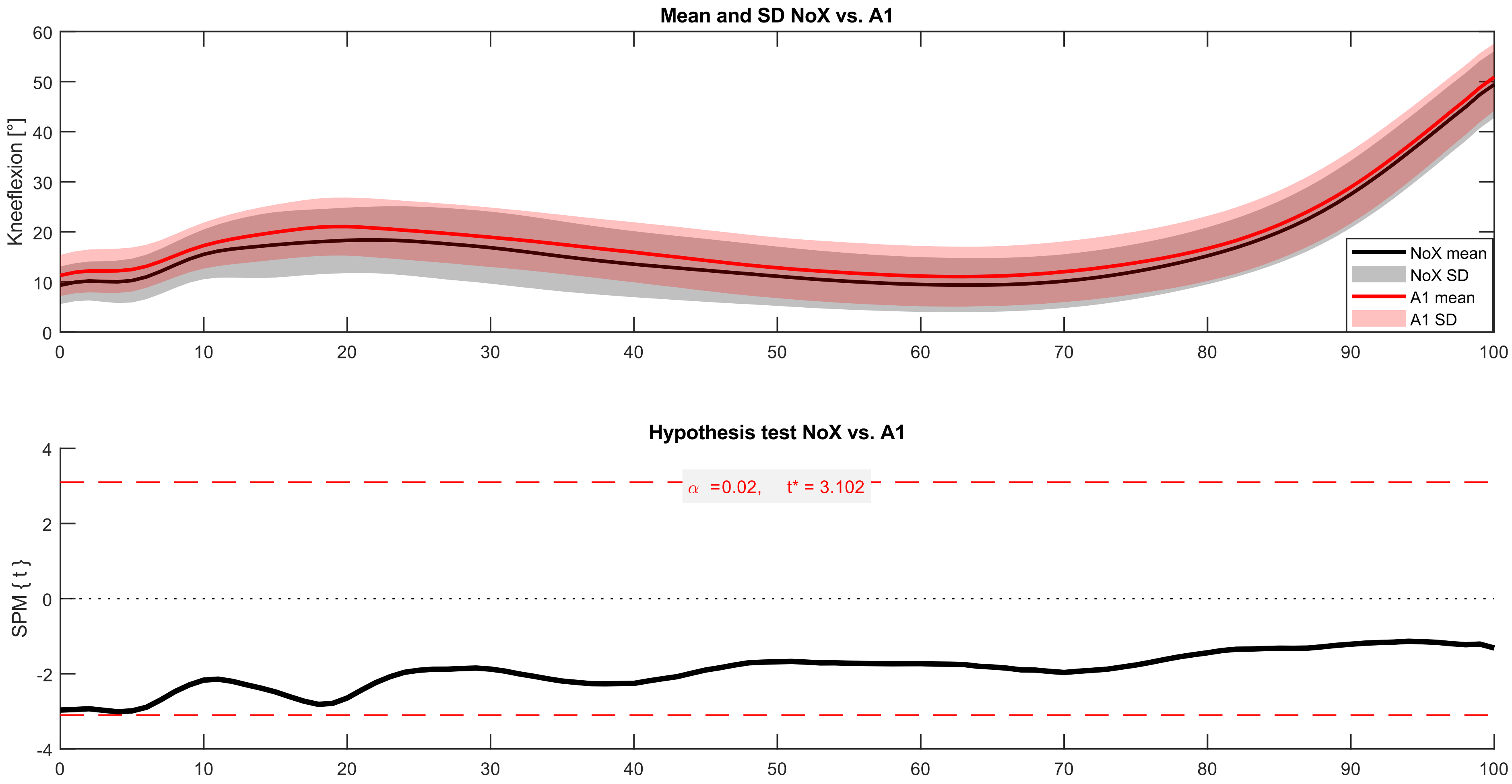
# Within-subjects ANOVA (repeated measures)



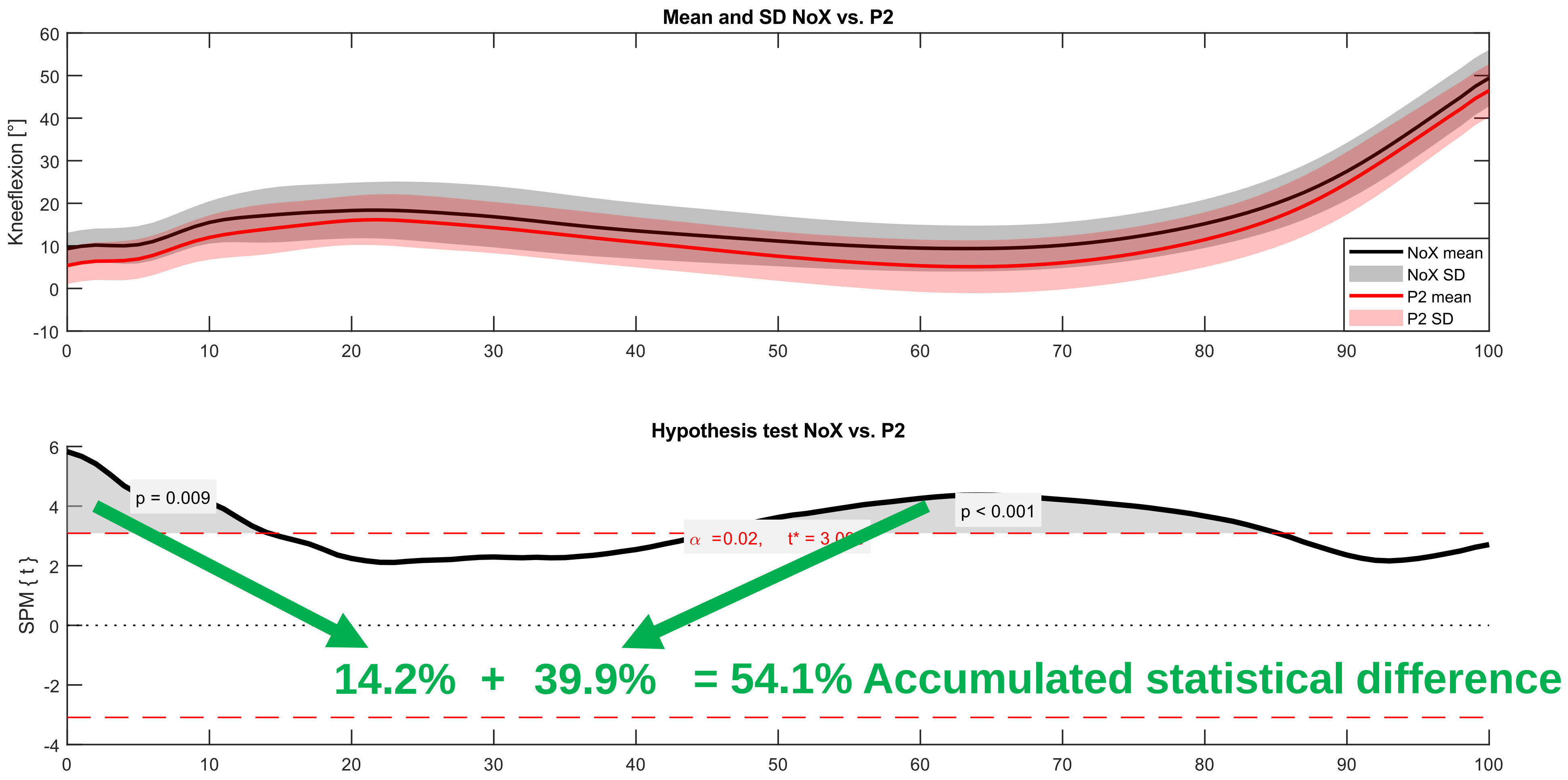
# Post-hoc analysis with Bonferroni correction



# Example 1: Kneeflexion angle NoX vs. A1



# Example 2: Kneeflexion angle NoX vs. P2



# Accumulated statistical differences

| Dependent Variables | NoX vs. A1 | NoX vs. P1 | NoX vs. P2 |
| --- | --- | --- | --- |
| Kneeflexion angle [°] | 0% | 0% | 54,1% |
| Kneeflexion moment [Nm/kg] | 1% | 0% | 0% |
| Hipflexion angle [°] | 0% | 34.5% | 100% |
| Hipflexion moment [Nm/kg] | 40.3% | 71.4% | 86.8% |

Johns et al. (2024?) - Reconstruction of occluded pelvis markers during marker-based motion capture with industrial exoskeletons

# Discussion

- The impact on knee joint kinematics could be attributed to the characteristics (design) of the exoskeleton
- The impact on knee joint loading is relatively low

- Exoskeletons in this study were tightened to the subjects primarily using a hip belt
  - Exoskeletons therefore might influence hip joint kinematics but further work in marker reconstruction is needed to evaluate the hip joint in detail

Further analysis of the entire kinematic chain (hip – knee – ankle) will be conducted

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# Thank you for your attention!