Influence of pubic symphysis stiffness on pelvis stress distribution during single leg stance

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1 - INTRODUCTION

Pelvis **➔** complex circular structure:

- 3 bones:
  - Left/right hipbones,
  - Sacrum,
- 3 joints:
  - Left/right Sacroiliac joints (**SI joints**),
  - Pubic Symphysis (**PS**).

Stability is essential to prevent lower back pain and further complications.

↳ evaluation of eventual relative motion with single leg stance radiographs.

Aim of the study: to assess the influence of Pubic Symphysis (PS) stiffness on the integrity of the bony structures and joints.

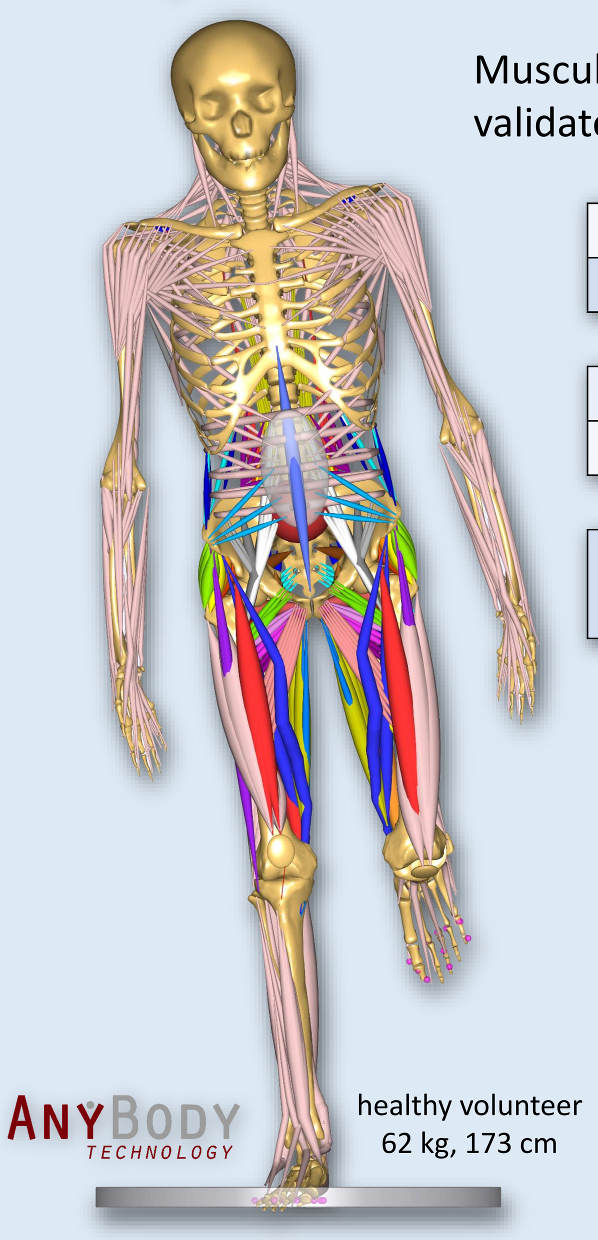
Numerical single leg stance model with loads from muscles and hips + Soft PS / Normal PS / Stiff PS = Changes in stress distribution ?

2 - METHODS

Load distribution in pelvis under physiological loading conditions

Inverse dynamics :
- Joints reaction forces,
- Muscles forces.

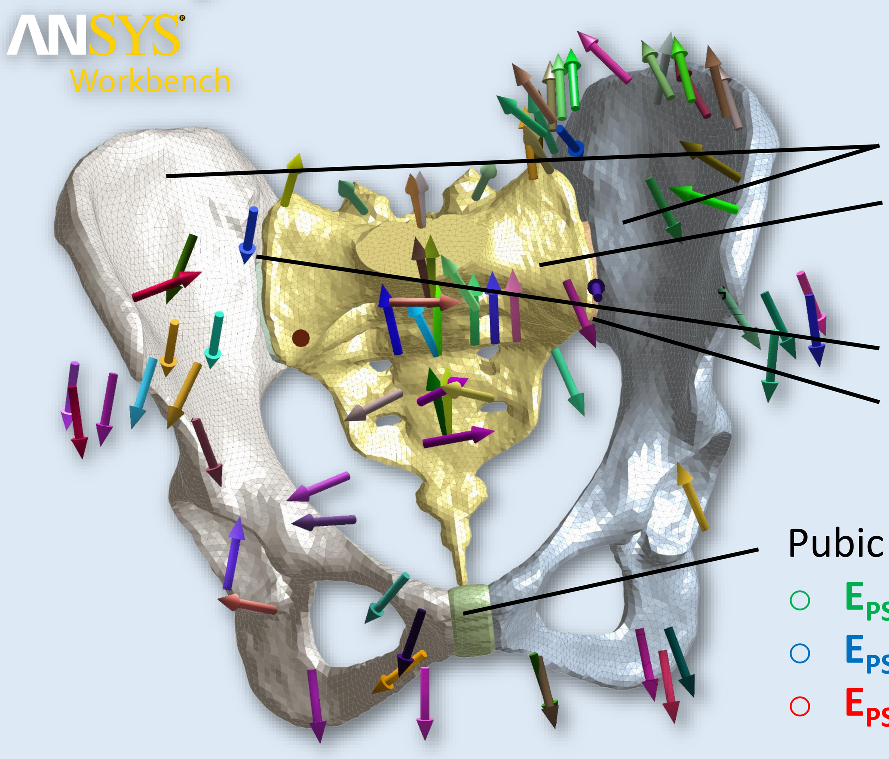
Musculoskeletal model from *AnyBody* experimentally validated [1] applied to right single leg stance:



Forces applied to the pelvis		
Side	Left	Right
Hip joints reaction forces [N]	366	1692
Muscles forces [N]	760	1 227
Sum of forces [N]	1126	2919
	4045	

Considered muscles:
- Adductor,
- Biceps Femor,
- Erector Spinae,
- Gemellus,
- Gluteus,
- Gracilis,
- Iliacus,
- Latissimus Doris,
- Multifidi,
- Obliqus Externus,
- Obliqus Internus,
- Obturator,
- Pectineus,
- Piriformis,
- Psoas Major,
- Quadratus Femoris,
- Quadratus Lumborum,
- Rectus Abdominis,
- Rectus Femoris,
- Sartorius,
- Semimembranosus,
- Semitendinosus,
- Tensor Fasciae Latae.

Finite Element Analysis: load distribution in pelvis



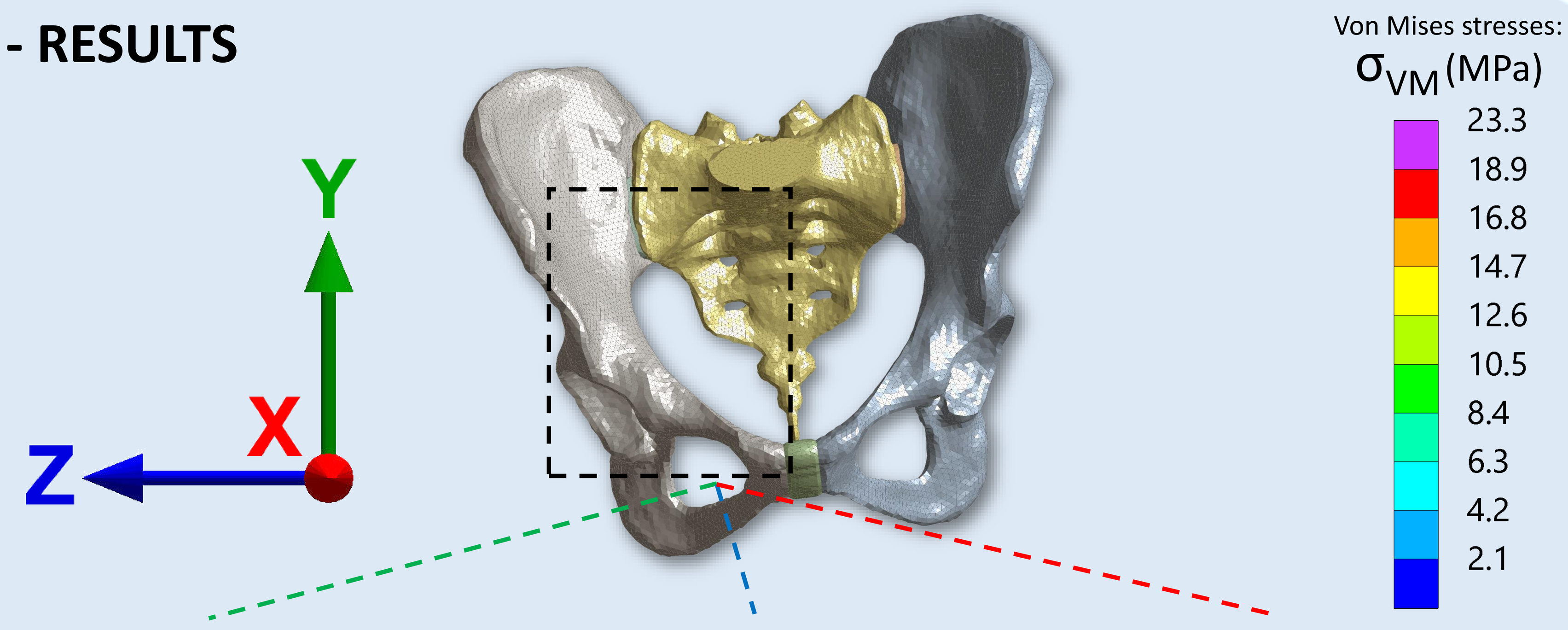
Bones (averaged mechanical properties from cancellous and spongeous bones: E_{Bones} = 7000 MPa, v_{Bones} = 0,3):
- left / right hip bones,
- sacrum.

Sacrolliac joints (E_{SIJ} = 350 MPa, v_{SIJ} =0,495):
- Left SI joint,
- Right SI joint.

Pubic Symphysis (single component, v_{PS} = 0,495 [2]):
- E_{PS} = **0,5** MPa (**Soft**),
- E_{PS} = **5** MPa (**Normal**) [4],
- E_{PS} = **50** MPa (**Stiff**).

Boundary conditions:
- Spherical joint at the lumbosacral joint,
- Physiological forces from inverse-dynamics simulation (*AnyBody*),
- Soft springs at lower ischial tuberosities for numerical convergence.

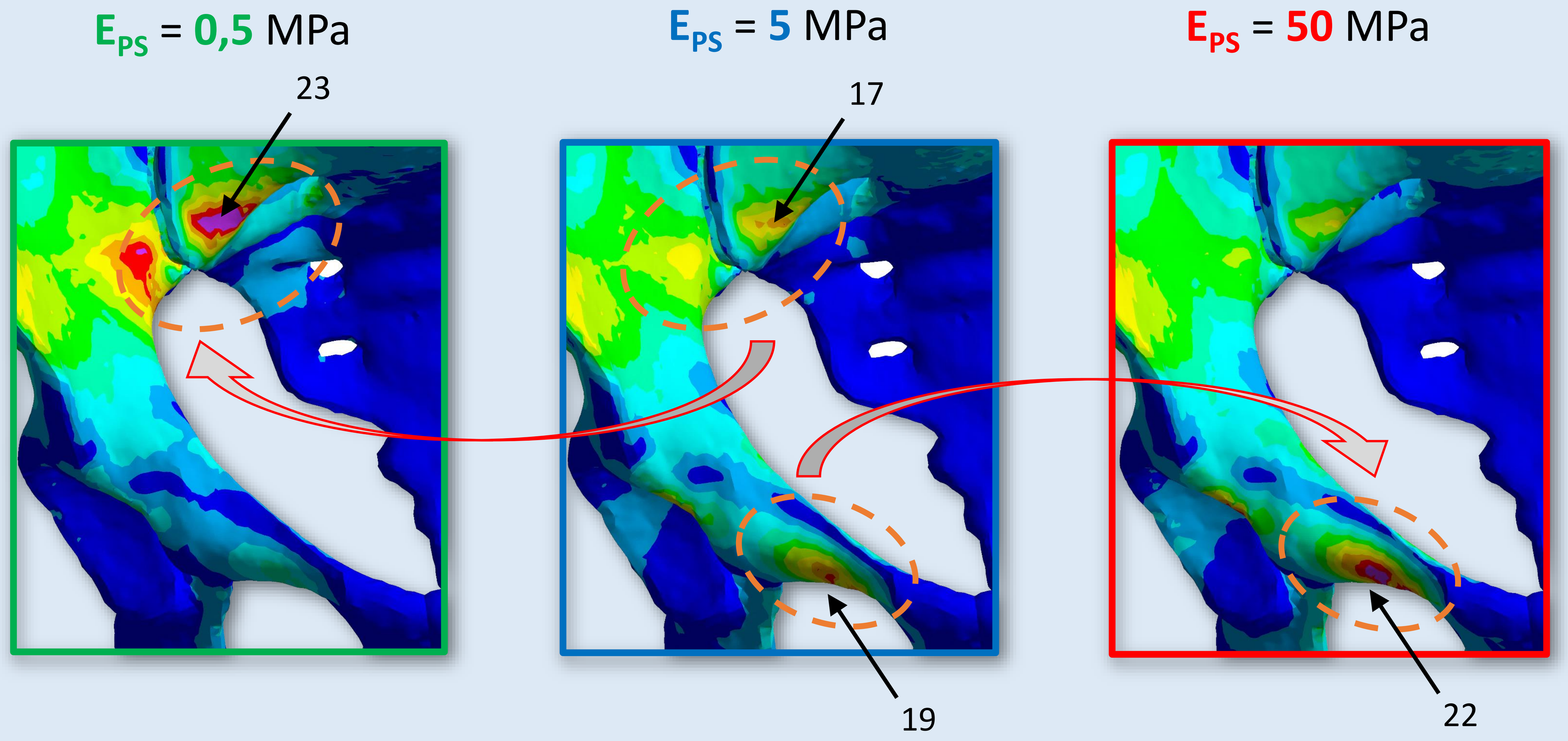
3 - RESULTS

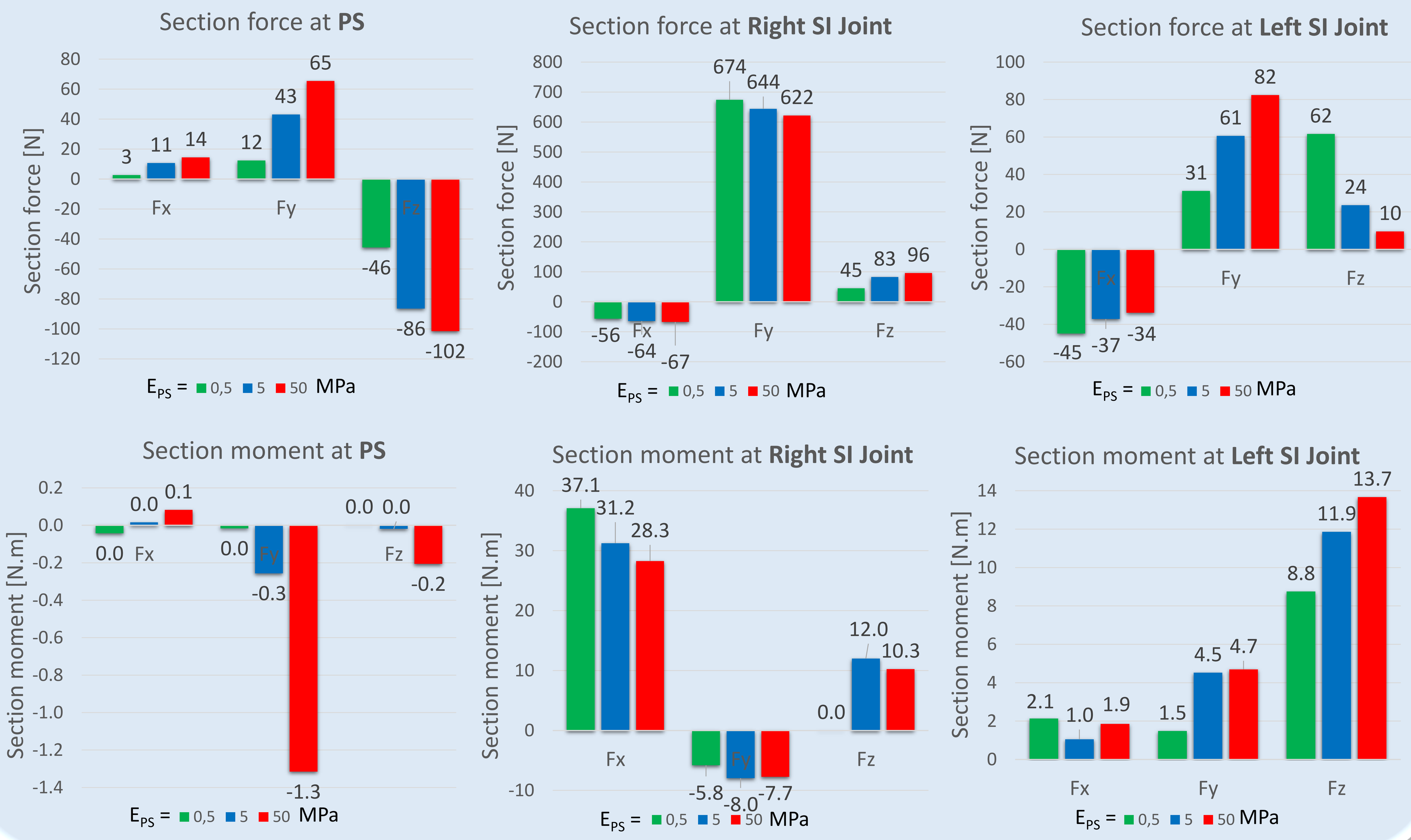


Soft Pubic Symphysis E_{PS} = **0,5** MPa

Normal Pubic Symphysis E_{PS} = **5** MPa

Stiff Pubic Symphysis E_{PS} = **50** MPa





4 – DISCUSSION and CONCLUSION

Normal PS: higher stresses at the superior ramus

↳ **Soft PS:**
- decreases stresses at the superior ramus,
- increases stresses on the sacrum.

e.g.: increased laxity, pregnant women, etc. ➔ lower back pain and problems on the back ?

↳ **Stiff PS:**
- increses stresses at the superior ramus,
- decreases stresses on the sacrum.

e.g.: elderly people, bridging of the PS, etc. ➔ superior rami more prone to fracture ?

PS, experiencing more **compression forces** than **shearing forces**.

→← ↑↓

➔ **essential role o**n the load distribution,

➔ **key element** of the biomechanics of the pelvis.

5 - REFERENCES

[1] Manders *et* Rasmussen, (2007) *Validation of hip joint force simulation by gait analysis*. Dresden, Germany.

[2] Fan *et al.*, (2015) *Biomechanical analysis of the fixation system for T-shaped acetabular fracture. Computational and Mathematical Methods in Medicine*, Volume 2015.

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