Foot Zebrafisch

The impact of orthopaedic soles on reducing spinal tilt in the frontal plane in adolescent idiopathic scoliosis (AIS)

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Who are we?

- **Vincent DILIGENT**, Podiatrist graduated in july 1977

  Training courses:
  - Posturology with René BOURDIOL
  - Posturology with Lionel CATANZARITI
  - Podo-osteopathy with Serge HELBERT and Alain FOURGOIN
  - Formétric 4D EtioSystem, Strasbourg
  - Muscular chains GDS (Godelieve DENYS STRÜFF) with Philippe CAMPIGNON

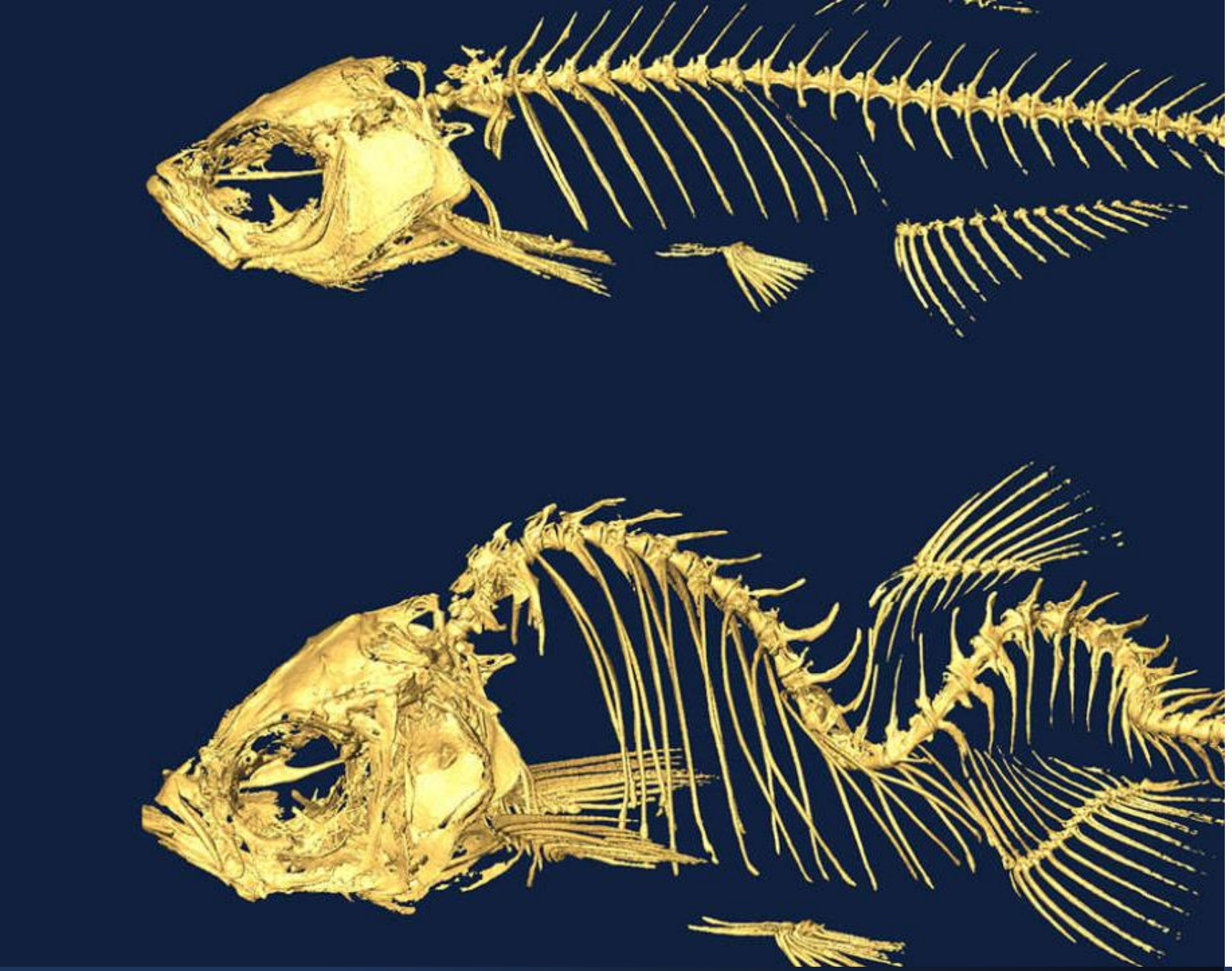
Joined the rehabilitation centre Marc SAUTELET in Villeneuve d'Ascq to work with **Dr Jean-François CATANZARITI** (Physical Medecine and Rehabilitation doctor) a specialist in scoliosis.

- **Adeline HOCHART**, Podiatrist graduated in 2009

  - Training courses:
    - Posturology with Drs Philippe MALAFOSSE and Pascal VELU
    - Pediatric Orthopedic by CHEM
    - Formetric 4D EtioSystem, Strasbourg
    - With Vincent DILIGENT on the principe of " compagnonage"

  - Joined the "Maison de la Scoliose" in Villeneuve d'Ascq with a multidisciplinary team managed by **Dr Jean-François CATANZARITI (MPR)**

LA MAISON DE LA SCOLIOSE



Why Zebrafish?

It is the only animal to develop “idiopathic“ scoliosis like humans, which is of non-traumatic or malformative origin.

- Zebrafish reproduces rapidly, it is easy to breed and to study from a genetic, locomotor and neuroscientific poit of view.

- However, it is not bipedal and lives in a microgravity environment: is it a relevant model for studying scoliosis?

- Indeed, bipedalism seems to be an important parameter in the occurrence of human idiopathic scoliosis. One way to assess this is to study the relevance of foot assessment and treatment in adolescent idiopathic scoliosis (AIS).

Adolescent idiopathic scoliosis (AIS)

- AIS is a three-dimensional deformity of the spine that affects 2 to 3% of adolescents aged 10 to 16 years old, with a female predominance (8 girls for 1 boy), evolving in a 1/3 of cases and with a multifactorial origin (genetic, tissue, hormonal, biomechanical and neurosensorial).
- AIS appears either as a single curvature, or as a double or even a triple curvature

L

R

Right thoracic

R

L

Left lumbar

Left lumbar + right thoracic

The left convex lumbar (or thoracolumbar) curvature seems to be the most suitable for podiatric treatment because it represents 80% of cases of lumbar or thoracolumbar scoliosis and our experience shows that pure thoracic curvatures respond less well to podiatric stimulation than lumbar curvatures.

It is often associated with a tilt of the pelvis to the left either in relation to an inequality of length of the lower limbs (ILLL) or either adaptive=> heel pad

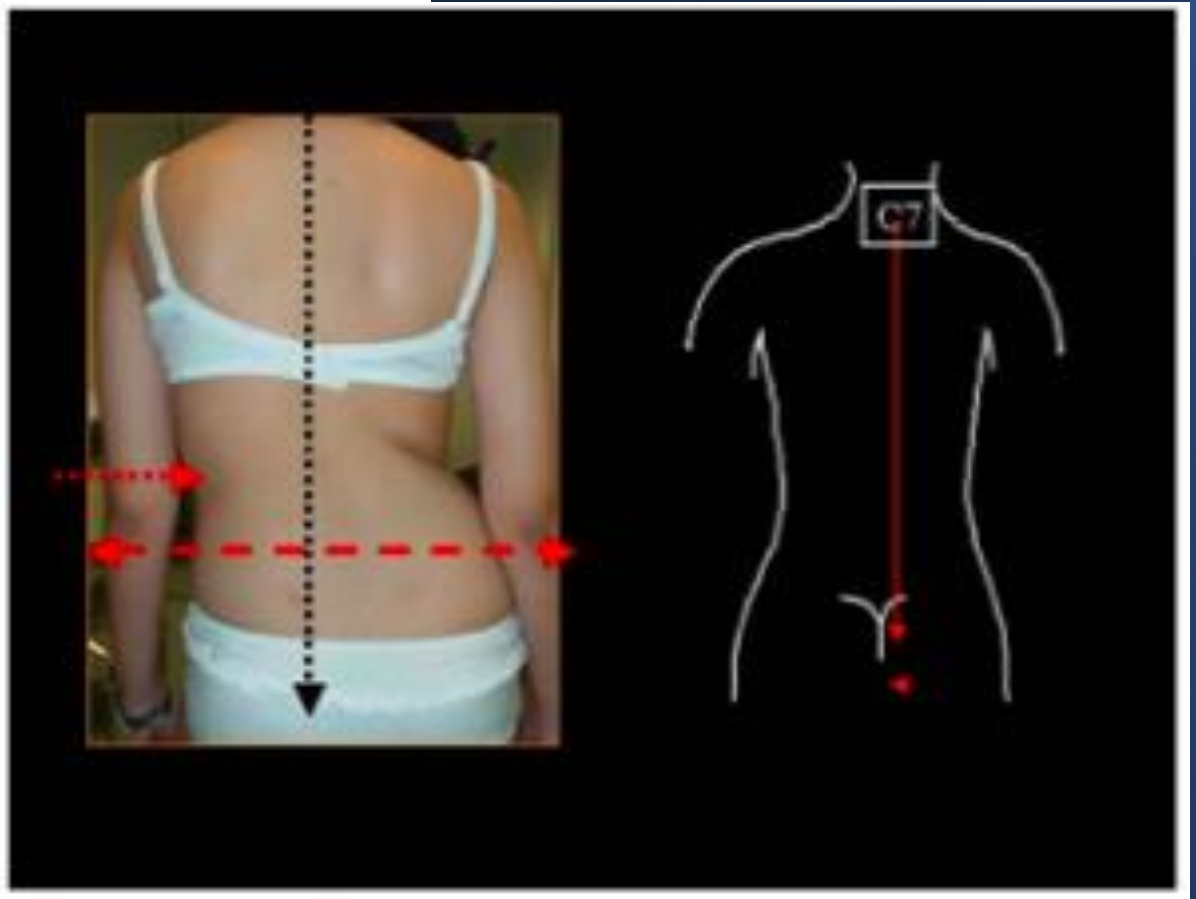
AIS is said to be:

- Balanced if the vertical from C7 passes through the intergluteal fold.
- Unbalanced if the vertical from C7 passes to the left or right of the intergluteal fold = **spinal tilt in the frontal plane.**
- Unbalanced AIS are at greater risk of painful decompensation and worsening of the Cobb angle. They may be worsened by lower limb length inequality which should be investigated and treated. This spinal tilt in the frontal plane is difficult to correct with rehabilitation or by wearing a brace. In fact, it is even a failure factor of brace treatment, but it can be corrected by using **asymmetric podal postural corrections.**

The role of the podiatrist will be, in the following order:

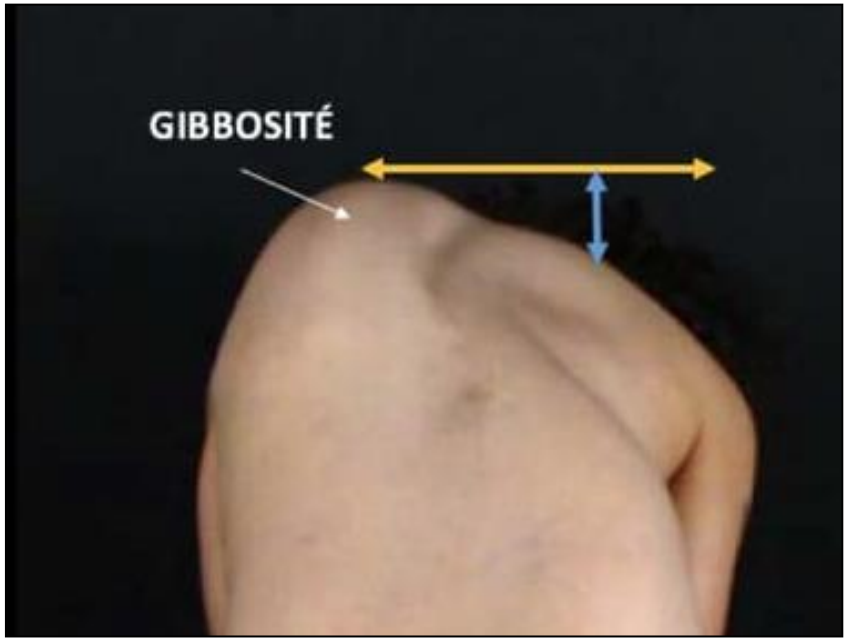
- DO NO HARM = DO NOT AGGRAVATE THE SCOLIOSIS

- to reduce spinal tilt in the frontal plane (different measuring techniques = plumb line, laser, surface topography)

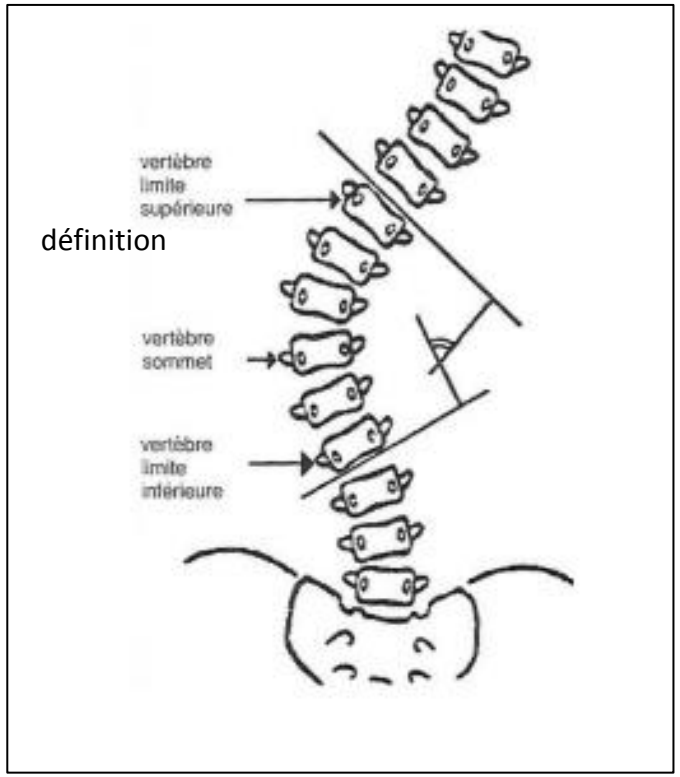


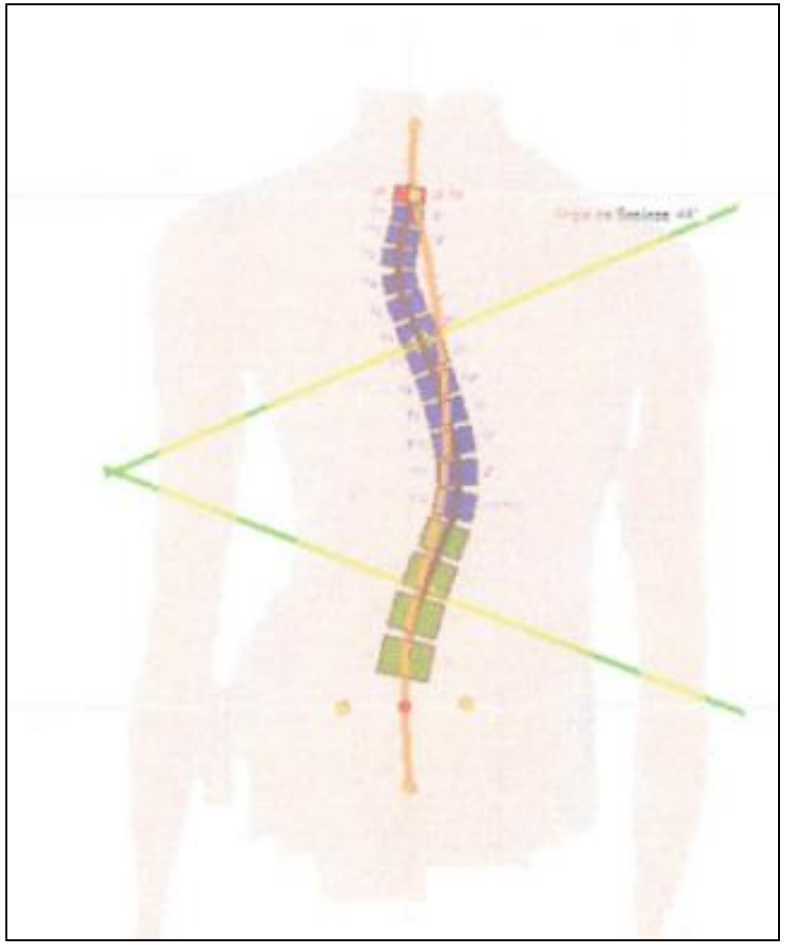
- Reduce the ATR (= angle of trunk rotation)

ATR is measured in degrees with a scoliometer



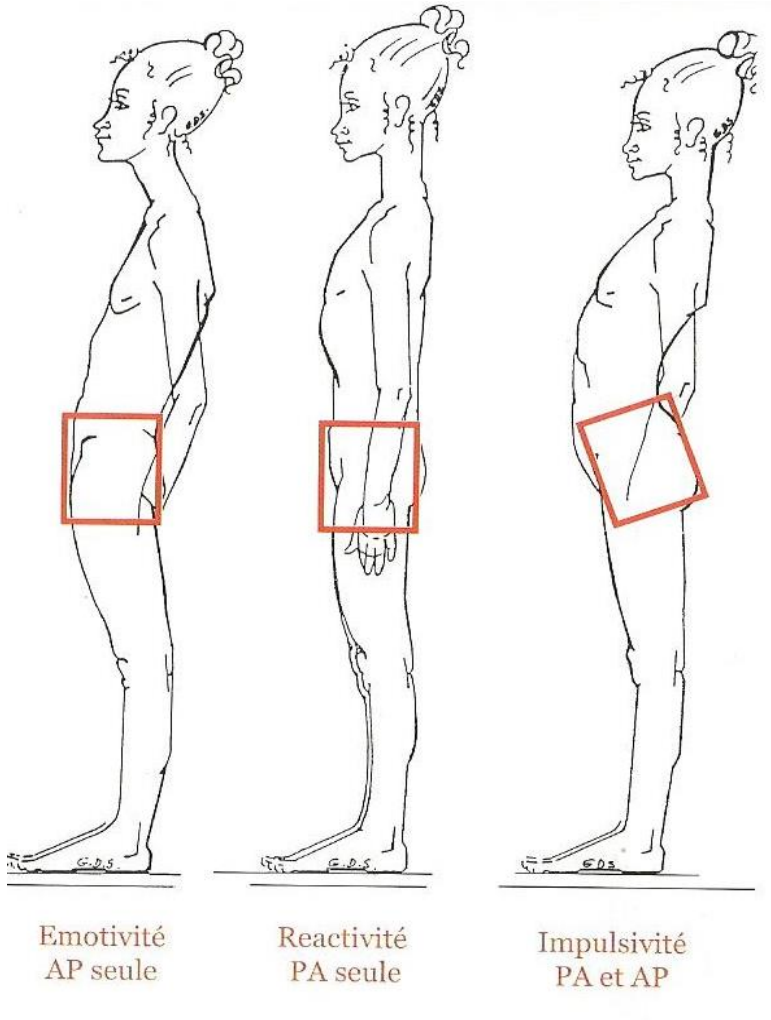
- Reducing the Cobb angle: (Assessment by imaging: EOS® radiography, surface topography (Formetric® photogrammetry





- Reducing pelvic torsion

- The study of the GDS (Godelieve Denys-Struyf) muscular and articular chains based on morpho-psychology, allowed us to observe that most scoliosis were part of the AP, PA or PAAP chains.



Emotionality Reactivity Impulsiveness

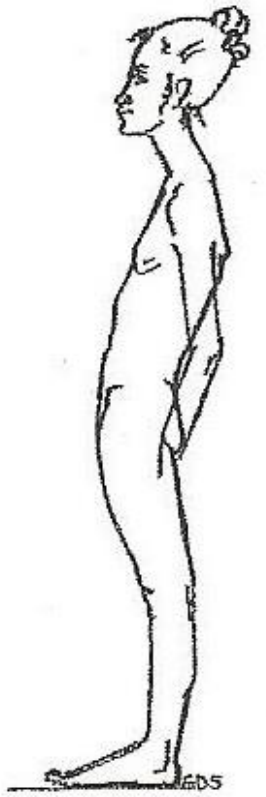
AP (anterior posterior) collapsed, undulating, lack of muscle tone

knees: flexion

back: kyphosis

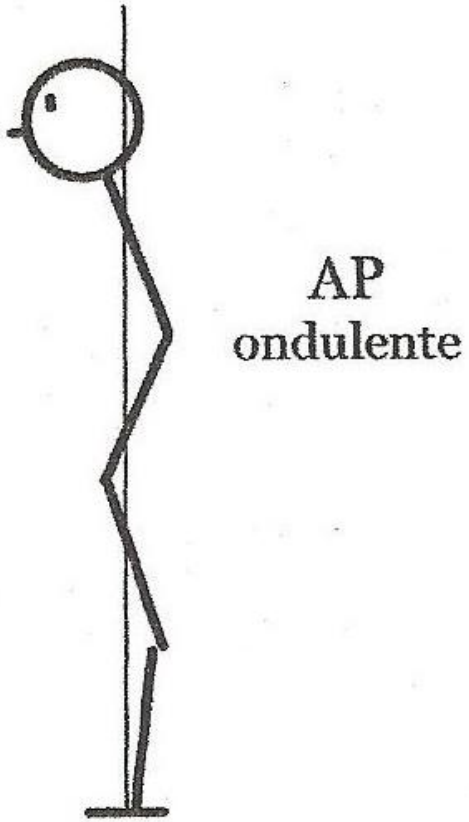
trunk: backwards

= a person who has not found his or her ideal, fragile, emotional, influenceable.



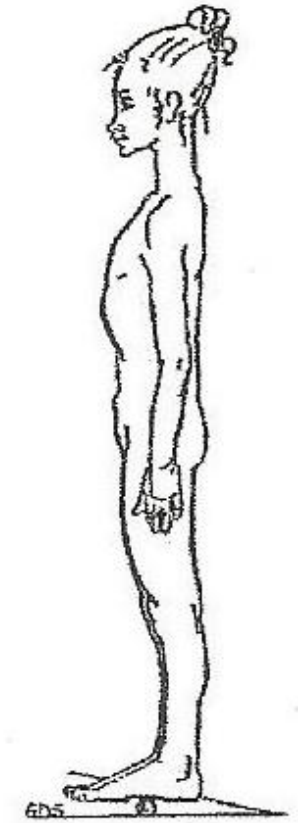
Emotivité

Emotionality



undulating

- **PA** (posterior anterior): erect posture, inspiratory thorax, cervical stiffness = a person who tends towards an ideal, has a global vision of events, is reactive.



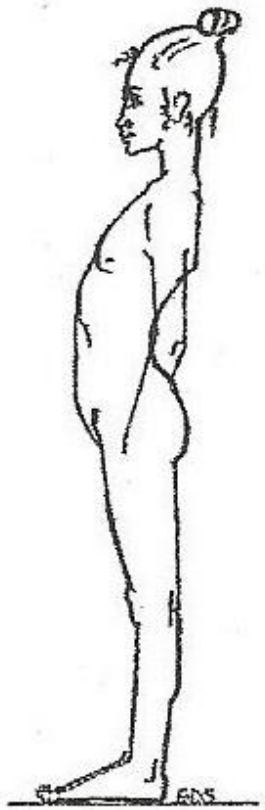
Réceptivité

PA
en rectitude

Receptivity

- **PA-AP**: erect at cervical and thoracic level but with a lumbar hyper lordosis.

- Permanent competition between anterior and posterior muscles, inspiratory chest block = a person who is impulsive, reactive, rather nervous, does not leave his or her ideal and tries to impose it on others.



Impulsiveness

For Mrs. Strüff, in scoliosis, it is necessary to give back ground anchorage to allow better support and this is done by placing **internal arches (IA)** under patients feet (even of small thickness).

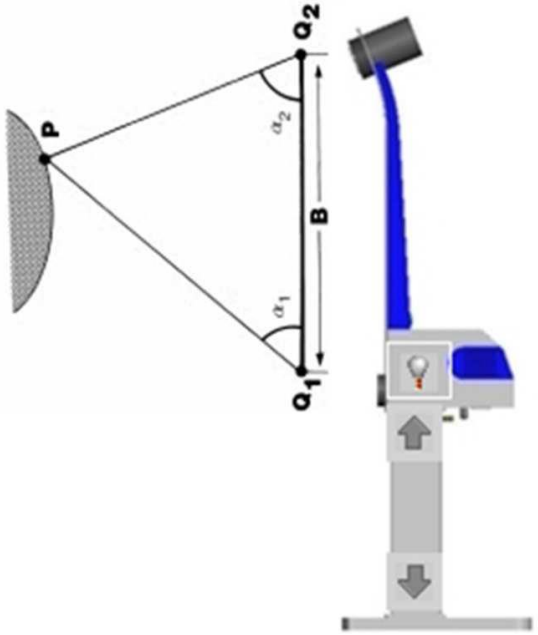
Our experience shows that to reduce the spinal tilt in the frontal plane it is most often necessary to:

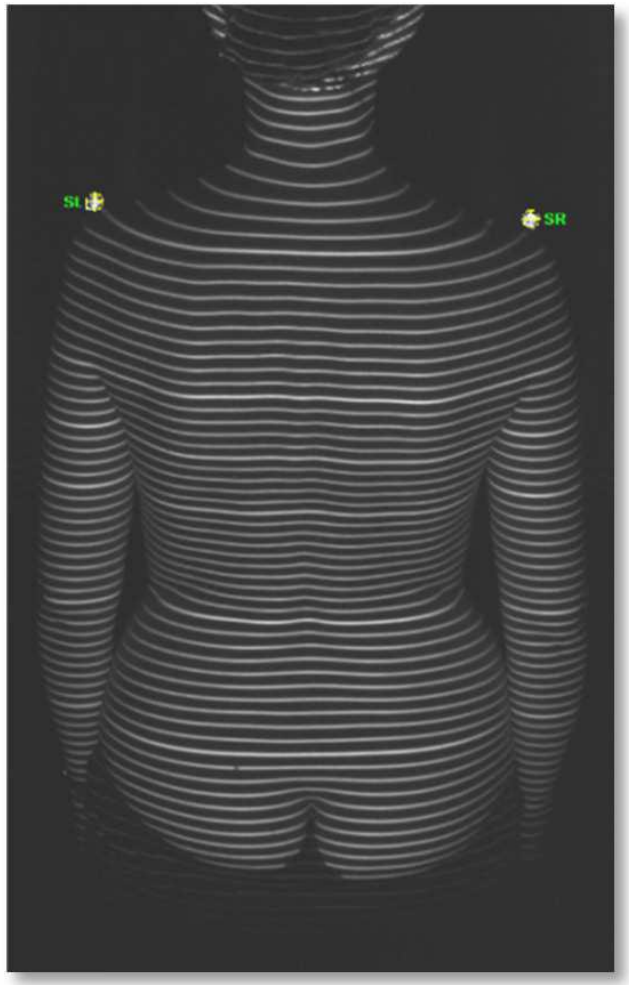
- put IA's of different heights (the thickest on the side of the tilt)
- and different densities (the firmest on the side of the tilt).
- possibly associated with a heel pad on the side of the tilt.

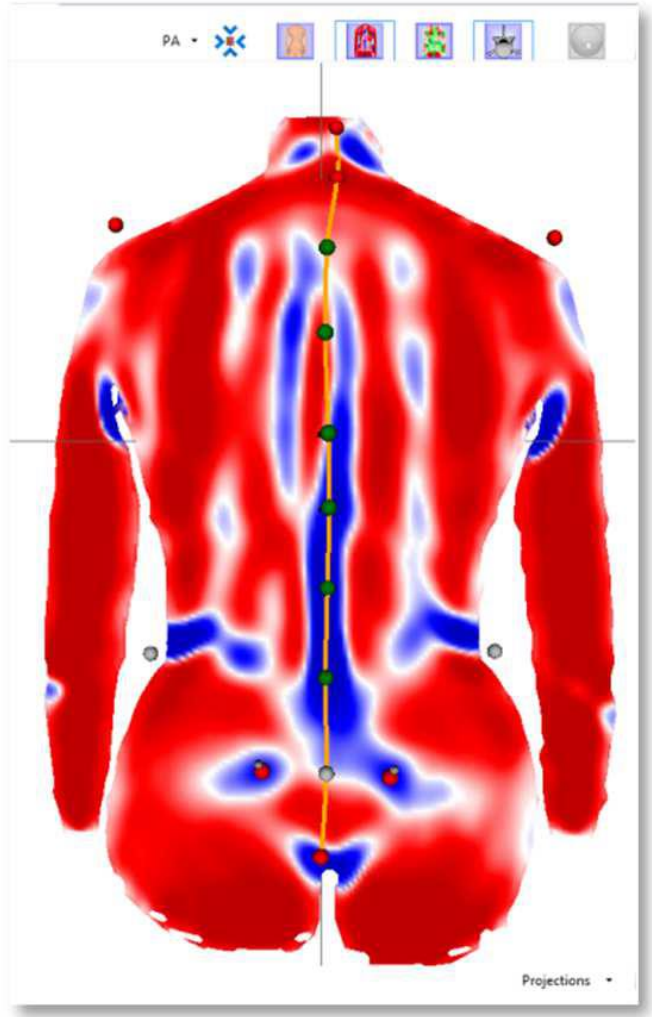
Validation of the orthopaedic sole scheme

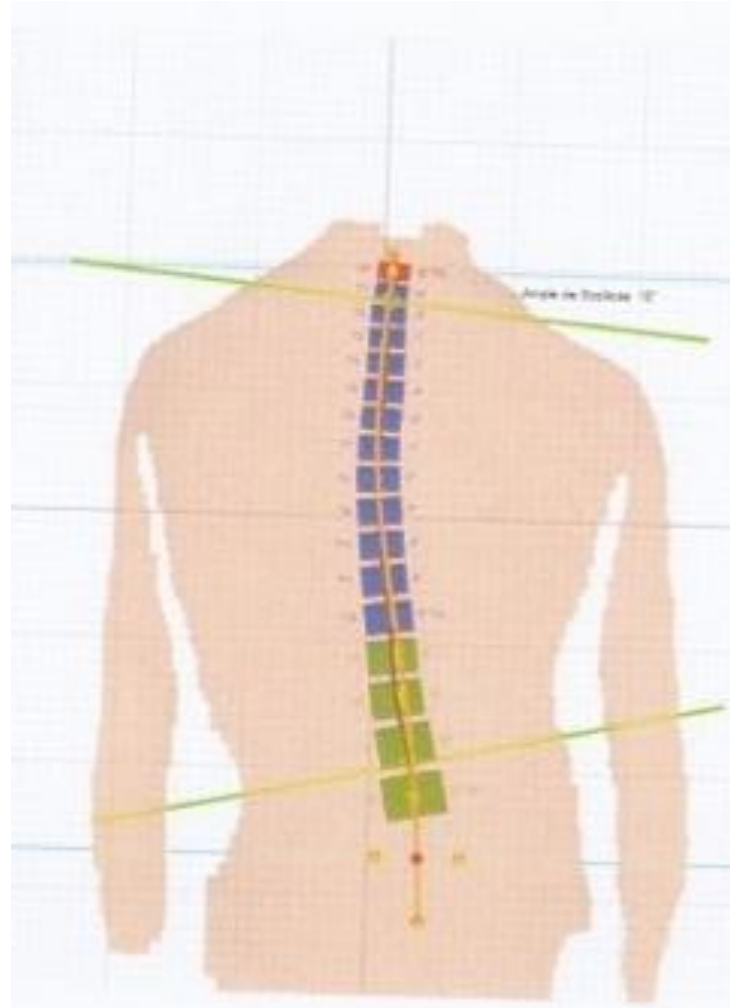
ALWAYS +++

- By surface topography (non-irradiating optical method, for example = DIERS Formétric 4D)




SL
SR

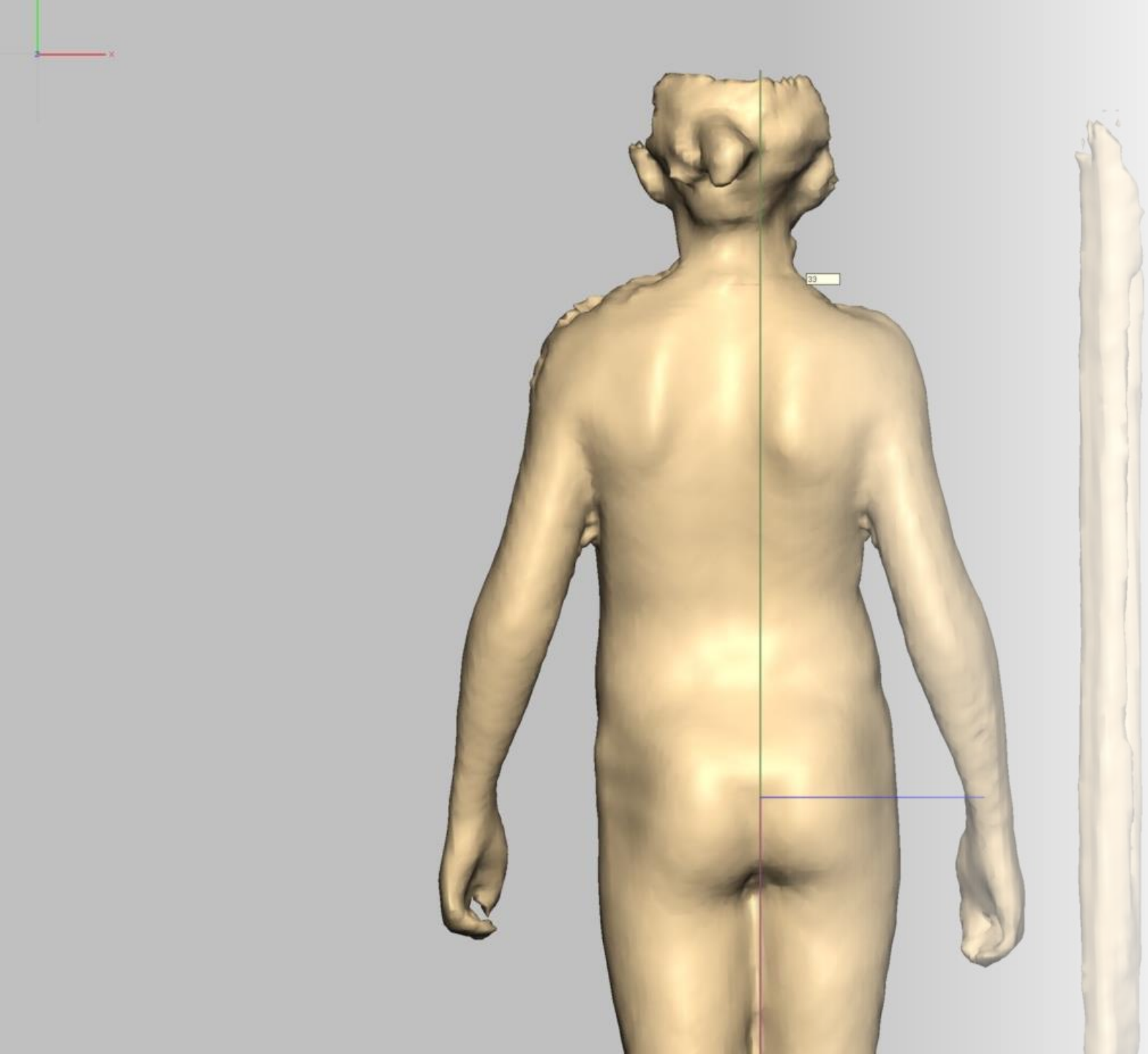

PA
Projections



- By EOS radiography of the total spine under load (= a gold standard of AIS monitoring, 10 times less irradiating than a standard radiography)

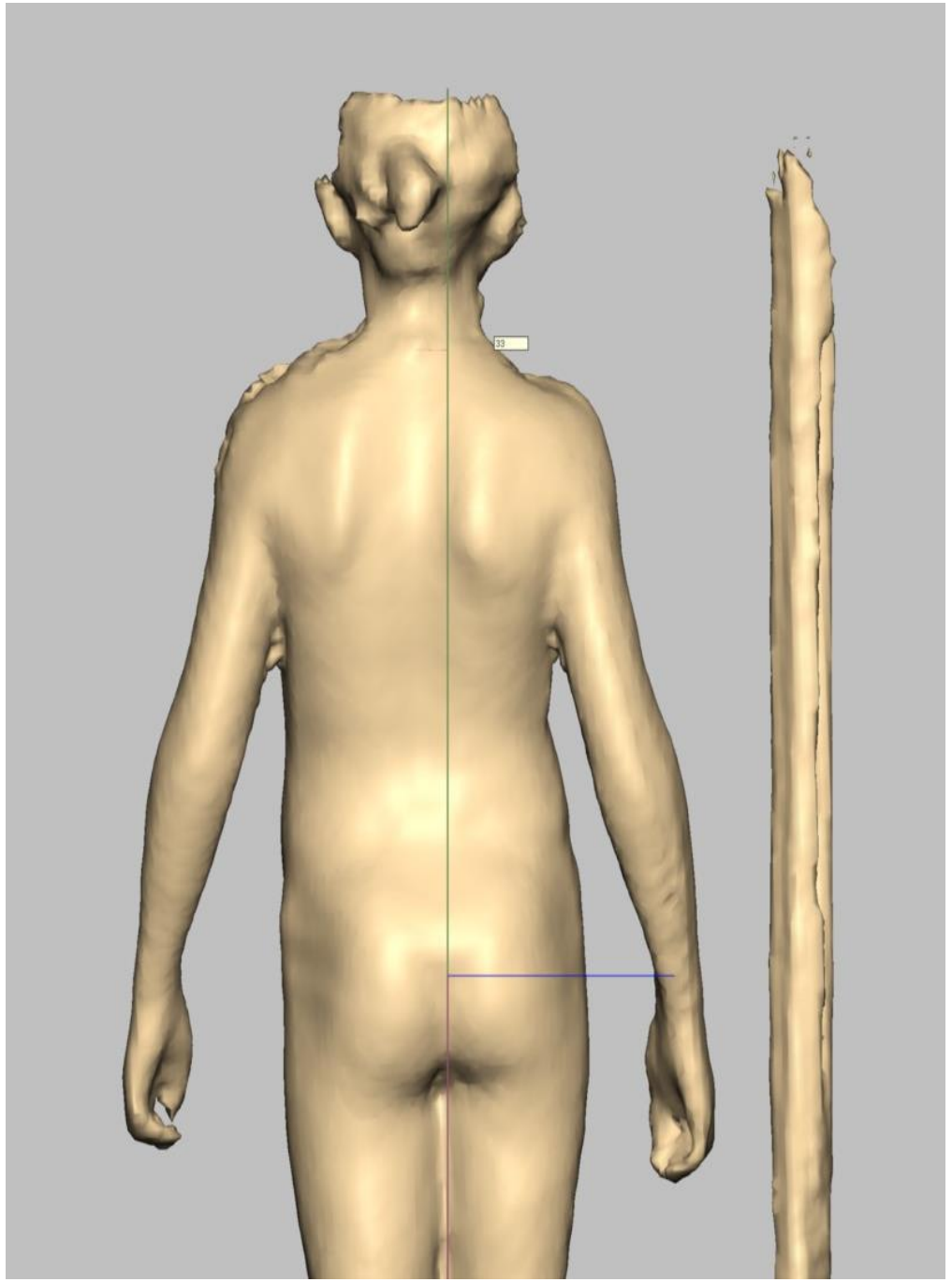
Without soles

with soles

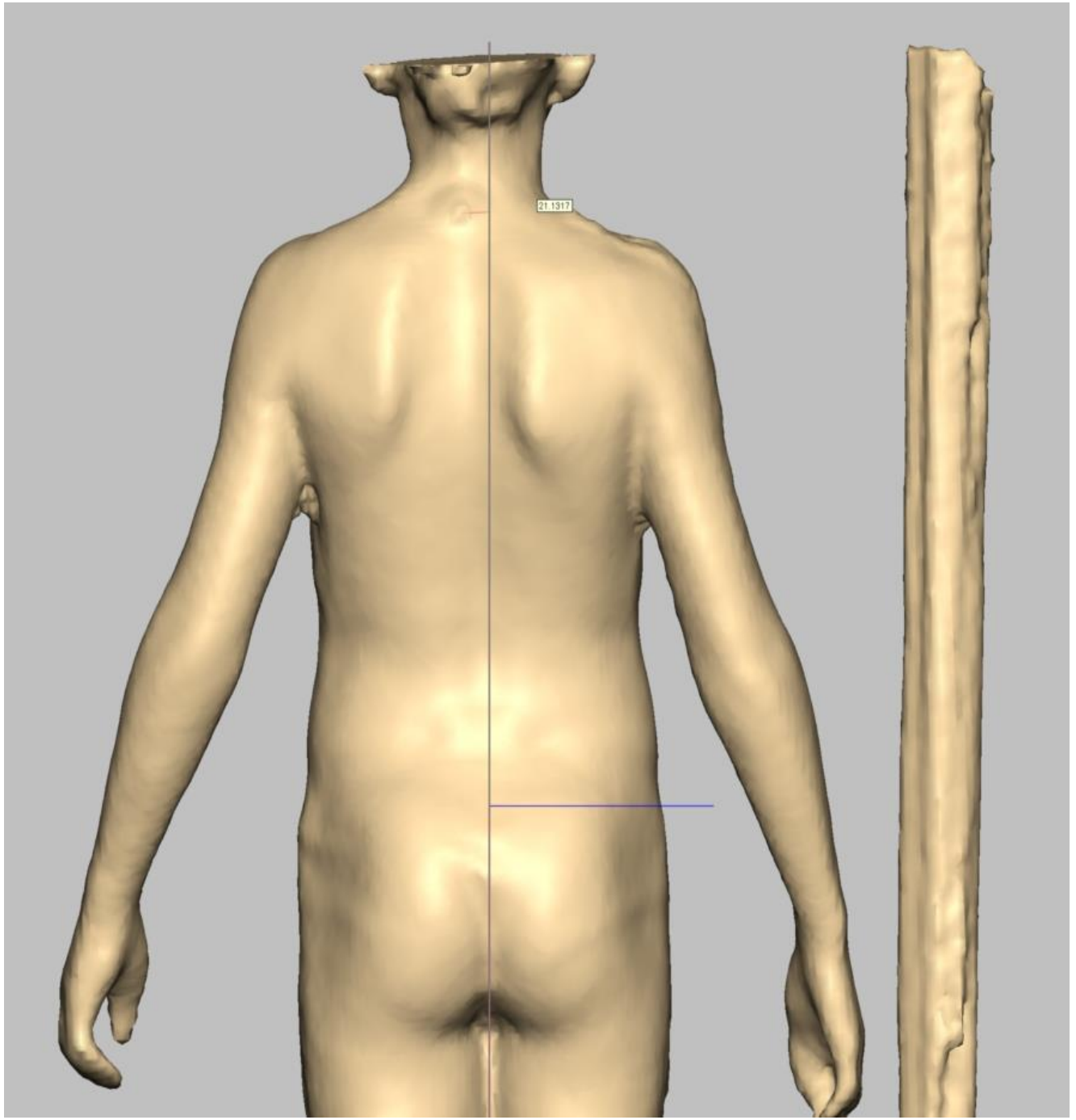


- with scan 3D

- Validation with scan 3D



Manon
Spinal tilt in the frontal plane without soles = 33 mm

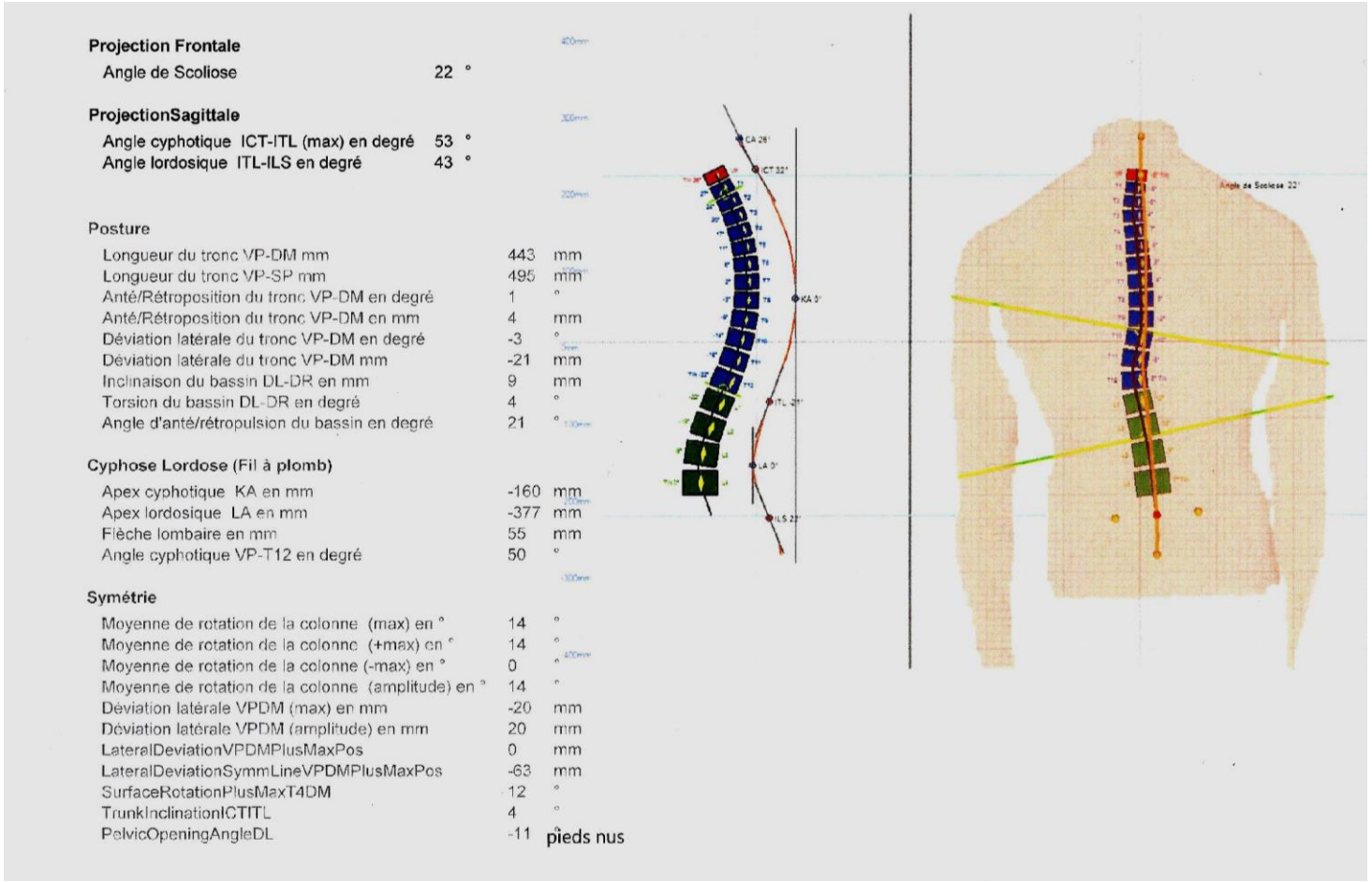


Manon:
spinal tilt in the frontal plane with asymmetric soles = 21,13 mm

In practice

- Validation by surface topography (Formetric® photogrammetry): "step-by-step postural correction" = we test different elements of the soles until we find the best combination.

Barefoot
Scoliosis: left TL 22°
Spinal tilt in the frontal plane = 21 mm

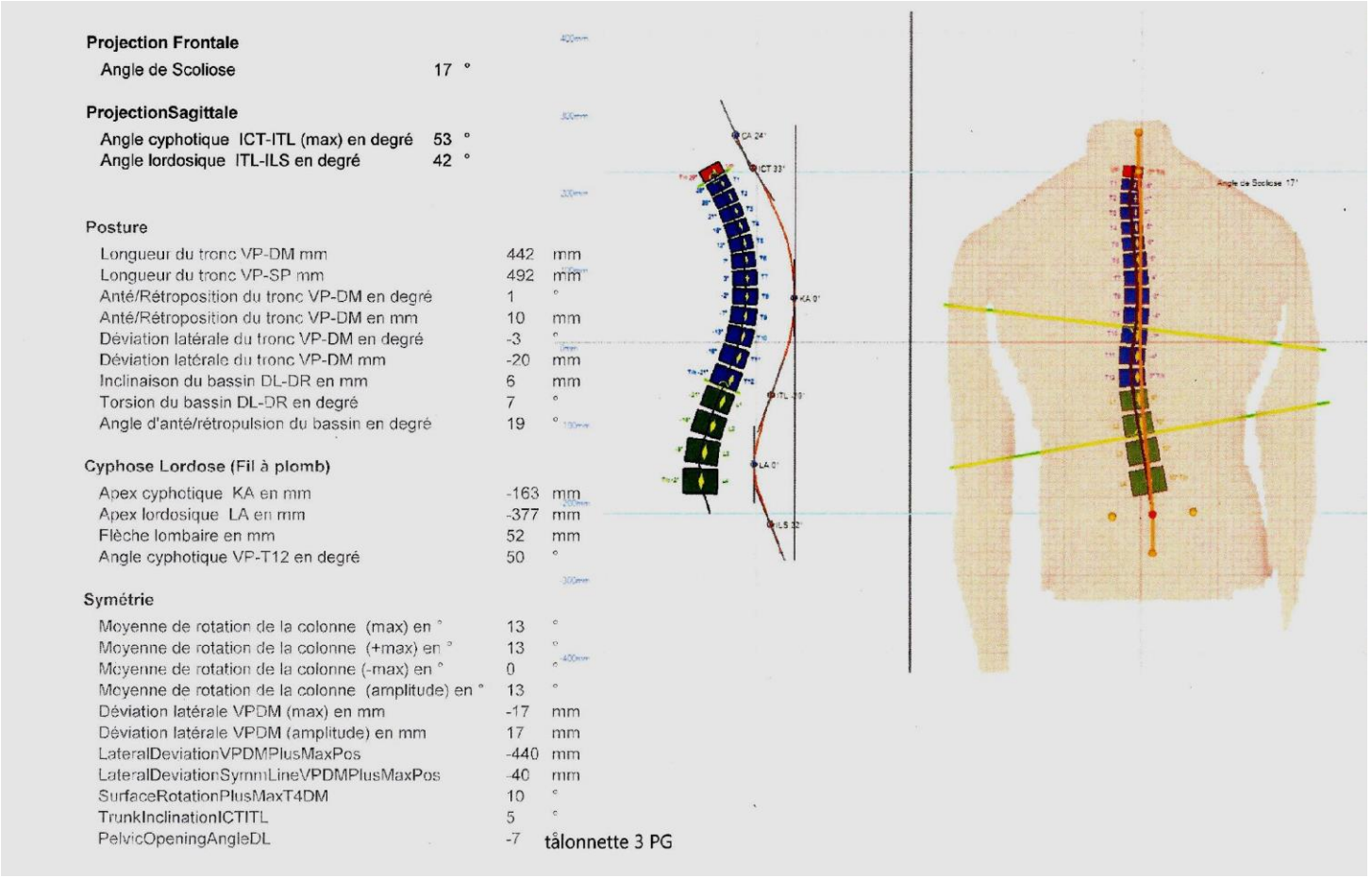


Projection Frontale		
Angle de Scoliose	22	°
ProjectionSagittale		
Angle cyphotique ICT-ITL (max) en degré	53	°
Angle lordosique ITL-ILS en degré	43	°
Posture		
Longueur du tronc VP-DM mm	443	mm
Longueur du tronc VP-SP mm	495	mm
Anté/Rétroposition du tronc VP-DM en degré	1	°
Anté/Rétroposition du tronc VP-DM en mm	4	mm
Déviation latérale du tronc VP-DM en degré	-3	°
Déviation latérale du tronc VP-DM mm	-21	mm
Inclinaison du bassin DL-DR en mm	9	mm
Torsion du bassin DL-DR en degré	4	°
Angle d'anté/rétropulsion du bassin en degré	21	°
Cyphose Lordose (Fil à plomb)		
Apex cyphotique KA en mm	-160	mm
Apex lordosique LA en mm	-377	mm
Flèche lombaire en mm	55	mm
Angle cyphotique VP-T12 en degré	50	°
Symétrie		
Moyenne de rotation de la colonne (max) en °	14	°
Moyenne de rotation de la colonne (+max) en °	14	°
Moyenne de rotation de la colonne (-max) en °	0	°
Moyenne de rotation de la colonne (amplitude) en °	14	°
Déviation latérale VPDM (max) en mm	-20	mm
Déviation latérale VPDM (amplitude) en mm	20	mm
LateralDeviationVPDMPlusMaxPos	0	mm
LateralDeviationSymmLineVPDMPlusMaxPos	-63	mm
SurfaceRotationPlusMaxT4DM	12	°
TrunkInclinationICTITL	4	°
PelvicOpeningAngleDL	-11	°

pieds nus

- Validation by surface topography (Formetric® photogrammetry): "step-by-step postural correction”

Left heel pad : 3 mm
Scoliosis : left TL 17°
Left spinal tilt in the frontal plane = 20 mm

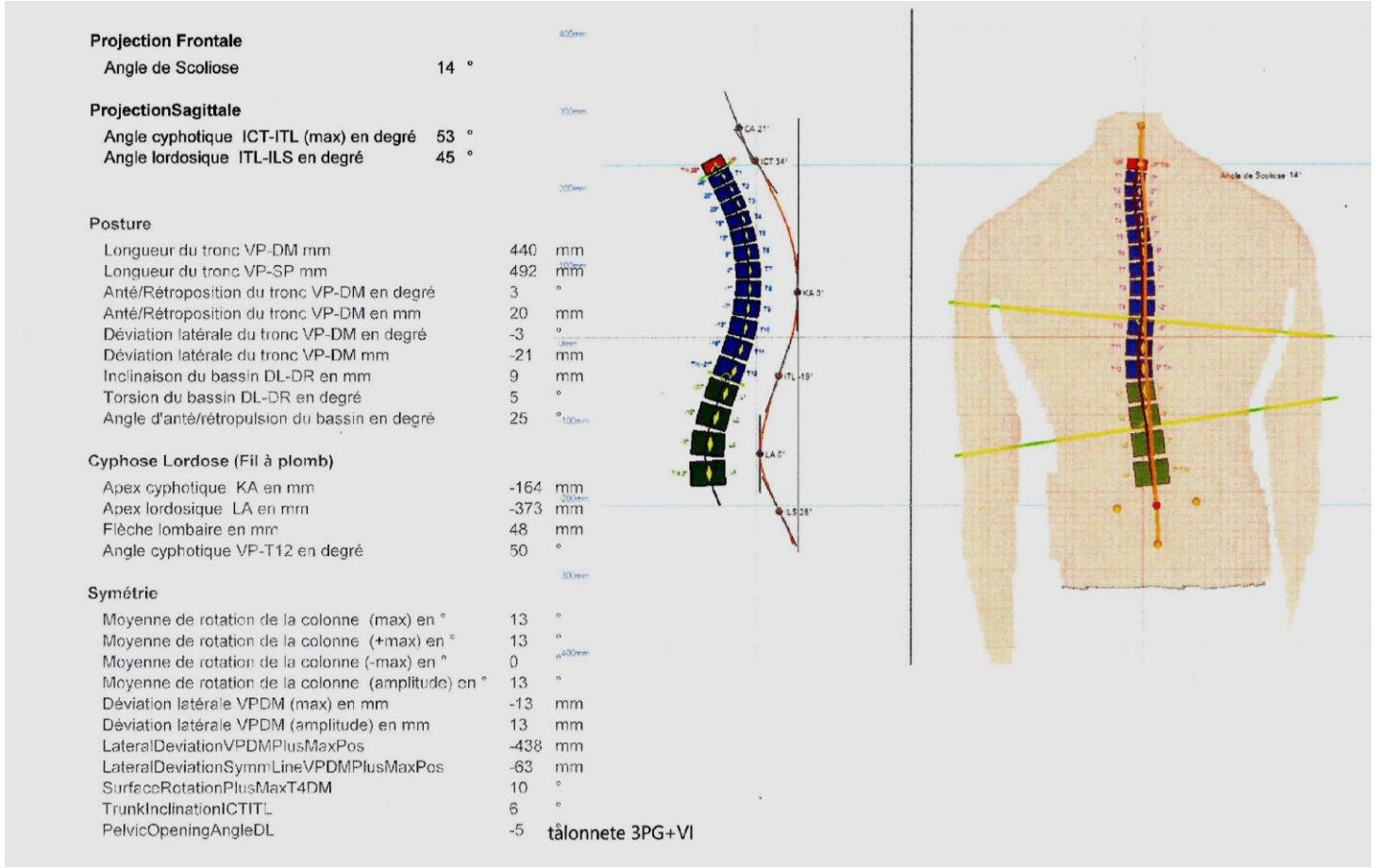


Projection Frontale		
Angle de Scoliose	17	°
ProjectionSagittale		
Angle cyphotique ICT-ITL (max) en degré	53	°
Angle lordosique ITL-ILS en degré	42	°
Posture		
Longueur du tronc VP-DM mm	442	mm
Longueur du tronc VP-SP mm	492	mm
Anté/Rétroposition du tronc VP-DM en degré	1	°
Anté/Rétroposition du tronc VP-DM en mm	10	mm
Déviation latérale du tronc VP-DM en degré	-3	°
Déviation latérale du tronc VP-DM mm	-20	mm
Inclinaison du bassin DL-DR en mm	6	mm
Torsion du bassin DL-DR en degré	7	°
Angle d'anté/rétropulsion du bassin en degré	19	°
Cyphose Lordose (Fil à plomb)		
Apex cyphotique KA en mm	-163	mm
Apex lordosique LA en mm	-377	mm
Flèche lombaire en mm	52	mm
Angle cyphotique VP-T12 en degré	50	°
Symétrie		
Moyenne de rotation de la colonne (max) en °	13	°
Moyenne de rotation de la colonne (+max) en °	13	°
Moyenne de rotation de la colonne (-max) en °	0	°
Moyenne de rotation de la colonne (amplitude) en °	13	°
Déviation latérale VPDM (max) en mm	-17	mm
Déviation latérale VPDM (amplitude) en mm	17	mm
LateralDeviationVPDMPlusMaxPos	-440	mm
LateralDeviationSymmLineVPDMPlusMaxPos	-40	mm
SurfaceRotationPlusMaxT4DM	10	°
TrunkInclinationICTITL	5	°
PelvicOpeningAngleDL	-7	°

tâlonnette 3 PG

- Validation by surface topography (Formetric® photogrammetry): "step-by-step postural correction”

Left heel pad 3 mm + IAx2= 15
Scoliosis: left TL 14°
Left spinal tilt in the frontal plane= 21 mm

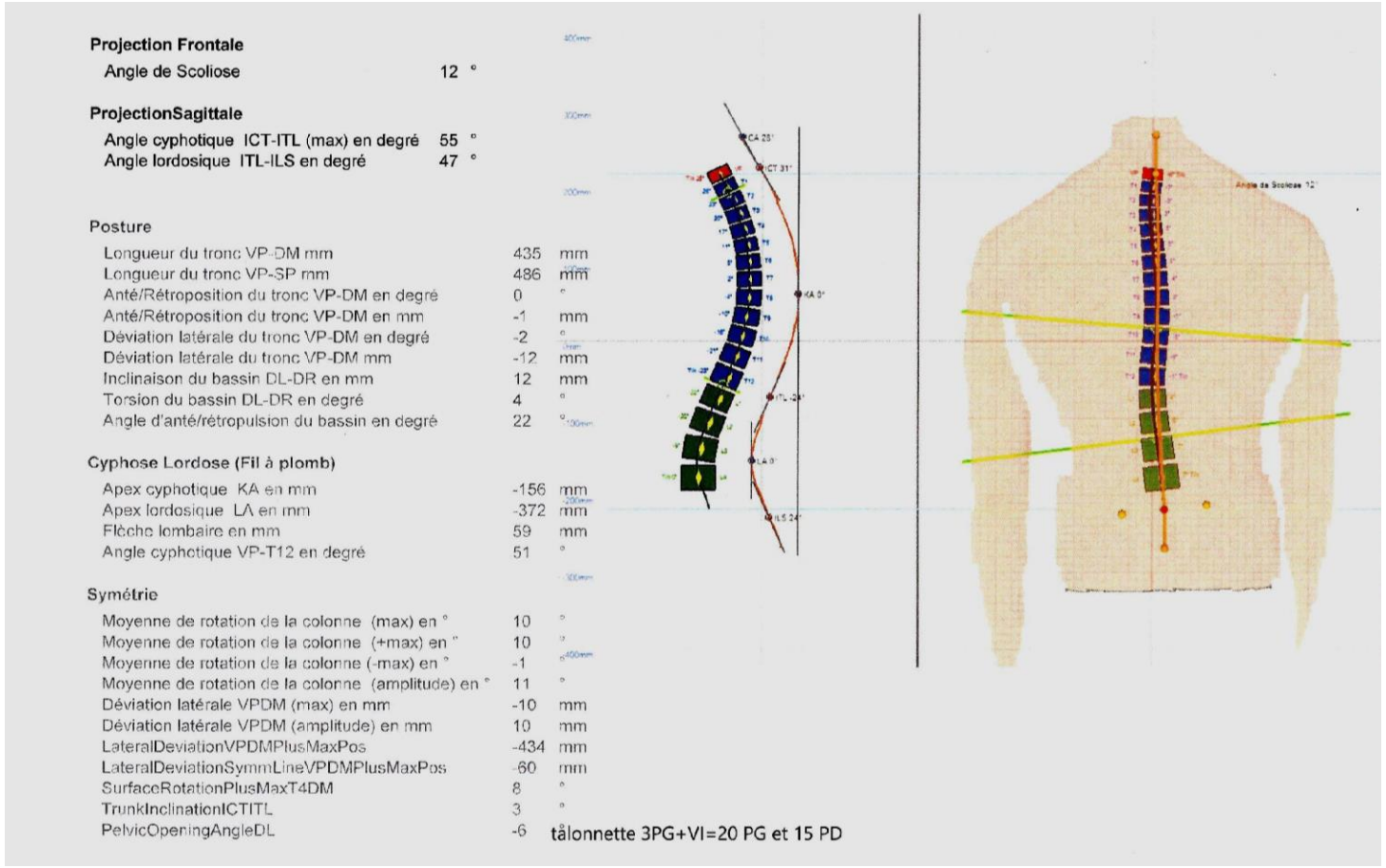


Projection Frontale		
Angle de Scoliose	14	°
ProjectionSagittale		
Angle cyphotique ICT-ITL (max) en degré	53	°
Angle lordosique ITL-ILS en degré	45	°
Posture		
Longueur du tronc VP-DM mm	440	mm
Longueur du tronc VP-SP mm	492	mm
Anté/Rétroposition du tronc VP-DM en degré	3	°
Anté/Rétroposition du tronc VP-DM en mm	20	mm
Déviation latérale du tronc VP-DM en degré	-3	°
Déviation latérale du tronc VP-DM mm	-21	mm
Inclinaison du bassin DL-DR en mm	9	mm
Torsion du bassin DL-DR en degré	5	°
Angle d'anté/rétropulsion du bassin en degré	25	°
Cyphose Lordose (Fil à plomb)		
Apex cyphotique KA en mm	-164	mm
Apex lordosique LA en mm	-373	mm
Flèche lombaire en mm	48	mm
Angle cyphotique VP-T12 en degré	50	°
Symétrie		
Moyenne de rotation de la colonne (max) en °	13	°
Moyenne de rotation de la colonne (+max) en °	13	°
Moyenne de rotation de la colonne (-max) en °	0	°
Moyenne de rotation de la colonne (amplitude) en °	13	°
Déviation latérale VPDM (max) en mm	-13	mm
Déviation latérale VPDM (amplitude) en mm	13	mm
LateralDeviationVPDMPlusMaxPos	-438	mm
LateralDeviationSymmLineVPDMPlusMaxPos	-63	mm
SurfaceRotationPlusMaxT4DM	10	°
TrunkInclinationICTITL	6	°
PelvicOpeningAngleDL	-5	°

tâlonnete 3PG+VI

- Validation by surface topography (Formetric® photogrammetry): "step-by-step postural correction”

Left heel pad 3 mm + left IA 20 + right IA 15
Scoliosis: left TL= 12°
Left spinal tilt in the frontal plane = 12 mm



Projection Frontale

Angle de Scoliose	12	°

ProjectionSagittale

Angle cyphotique ICT-ITL (max) en degré	55	°
Angle lordosique ITL-ILS en degré	47	°

Posture

Longueur du tronc VP-DM mm	435	mm
Longueur du tronc VP-SP mm	486	mm
Anté/Rétroposition du tronc VP-DM en degré	0	°
Anté/Rétroposition du tronc VP-DM en mm	-1	mm
Déviation latérale du tronc VP-DM en degré	-2	°
Déviation latérale du tronc VP-DM mm	-12	mm
Inclinaison du bassin DL-DR en mm	12	mm
Torsion du bassin DL-DR en degré	4	°
Angle d'anté/rétropulsion du bassin en degré	22	°

Cyphose Lordose (Fil à plomb)

Apex cyphotique KA en mm	-156	mm
Apex lordosique LA en mm	-372	mm
Flèche lombaire en mm	59	mm
Angle cyphotique VP-T12 en degré	51	°

Symétrie

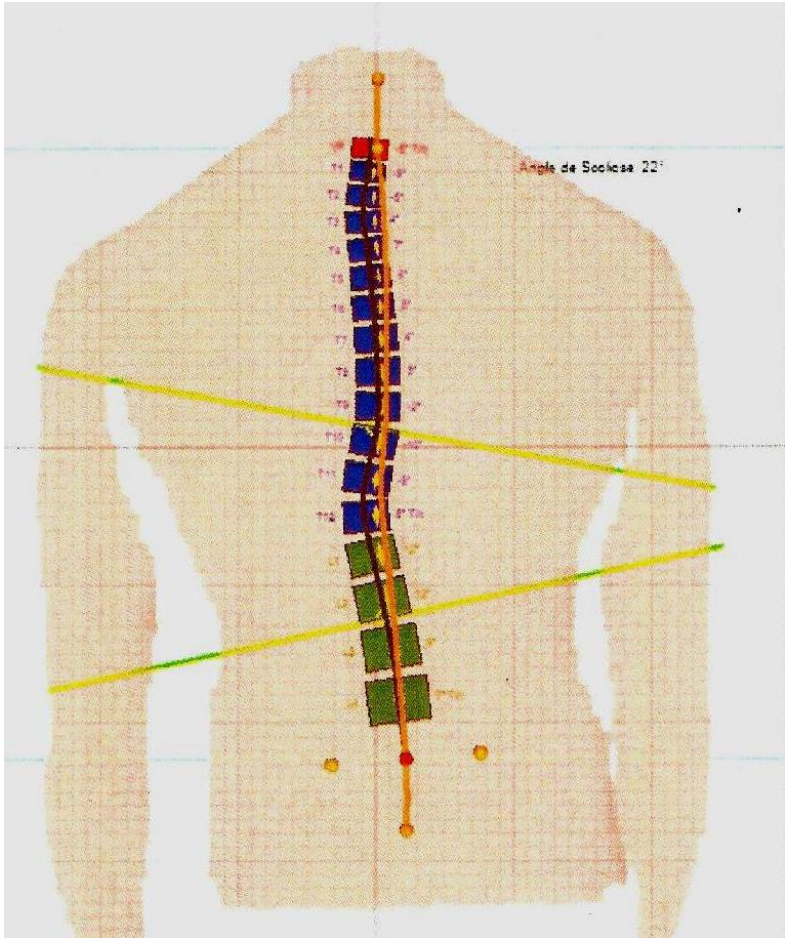
Moyenne de rotation de la colonne (max) en °	10	°
Moyenne de rotation de la colonne (+max) en °	10	°
Moyenne de rotation de la colonne (-max) en °	-1	°
Moyenne de rotation de la colonne (amplitude) en °	11	°
Déviation latérale VPDM (max) en mm	-10	mm
Déviation latérale VPDM (amplitude) en mm	10	mm
LateralDeviationVPDMPlusMaxPos	-434	mm
LateralDeviationSymmLineVPDMPlusMaxPos	-60	mm
SurfaceRotationPlusMaxT4DM	8	°
TrunkInclinationICTITL	3	°
PelvicOpeningAngleDL	-6	°

tâlonnette 3PG+VI=20 PG et 15 PD

- Validation by surface topography (Formetric® photogrammetry): "step-by-step postural correction”

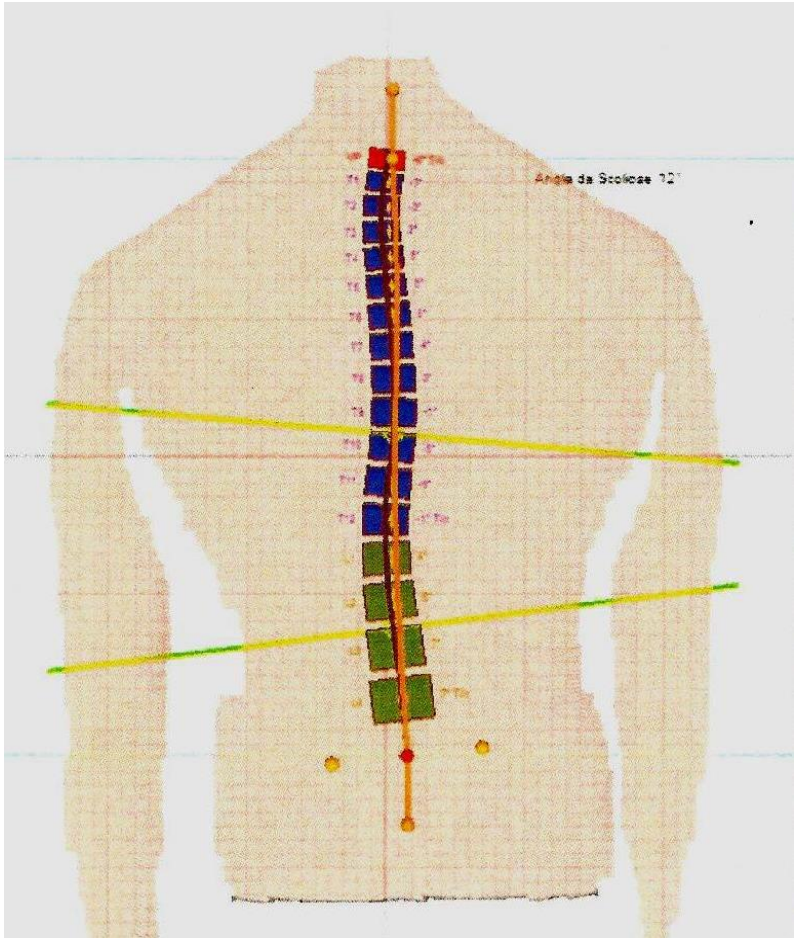
barefoot

Left TL= 22°
Left spinal tilt in the frontal plane =21 mm

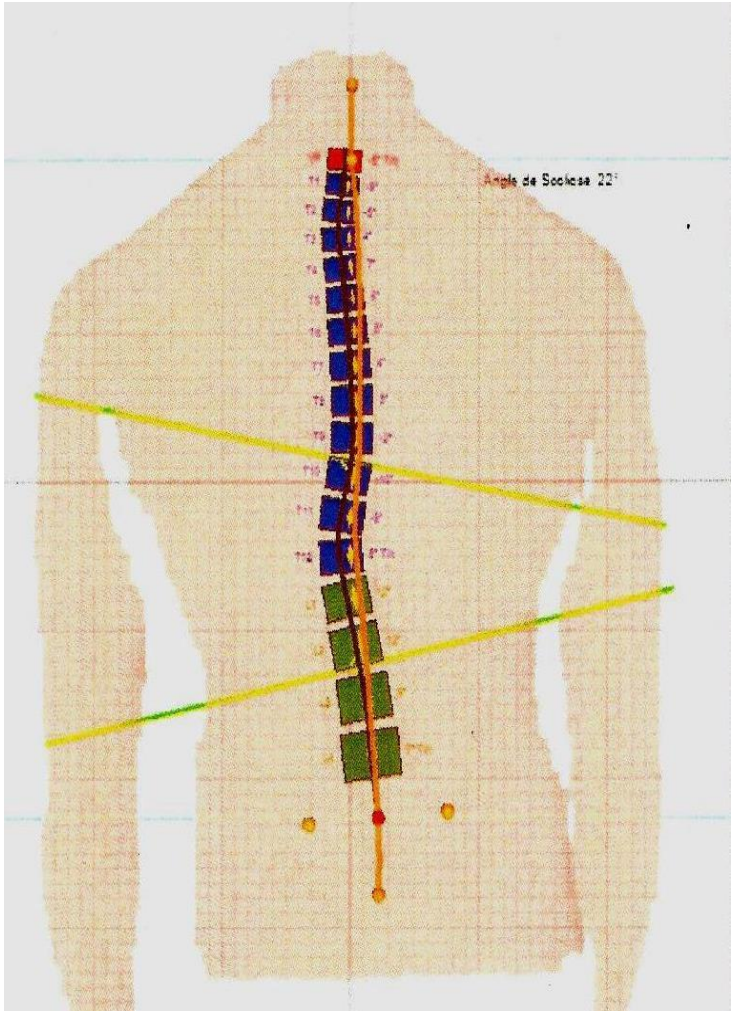


Left compensation =5
Left IA = 15
Right IA = 20

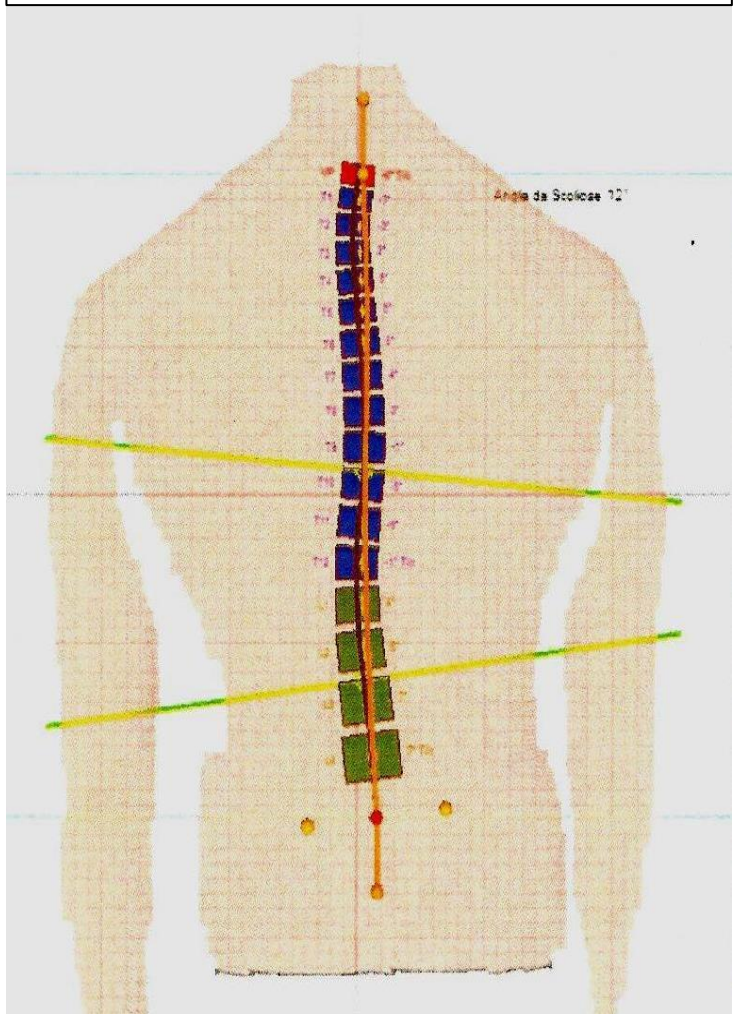
Left TL = 12°
Left spinal tilt in the frontal plane = 12 mm



barefoot
Left TL= 22°, left spinal tilt in the frontal plane = 22 mm



With left heel pad = 5 mm
Left IA =20 mm + right IA = 15 mm
Left TL = 12°, left spinal tilt in the frontal plane = 12 mm

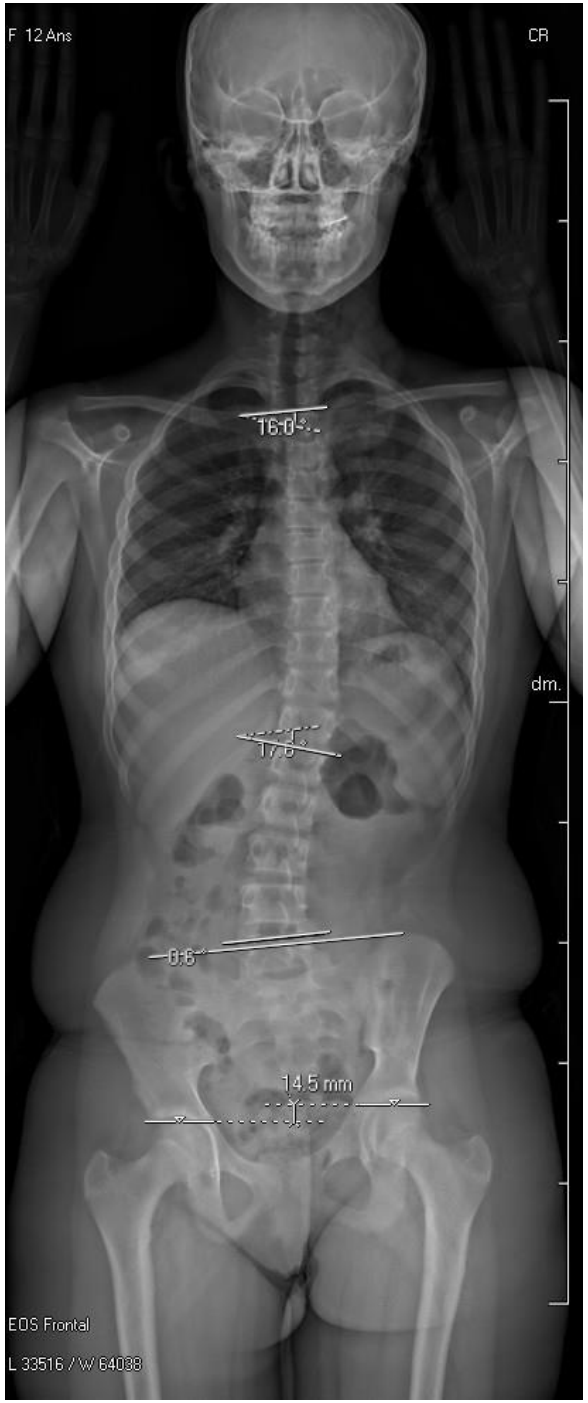


- Validation by EOS radio

Pauline 13 years old
Scoliosis: left TL 23° with a pelvic tilt 15mm, left lumbar ATR 8°, left spinal tilt in the frontal plane measured with a plumb line.
Clinical tests: left heel compensation pad + asymmetric left IA
→ Reduction of ATR and left spinal tilt in the frontal plane -

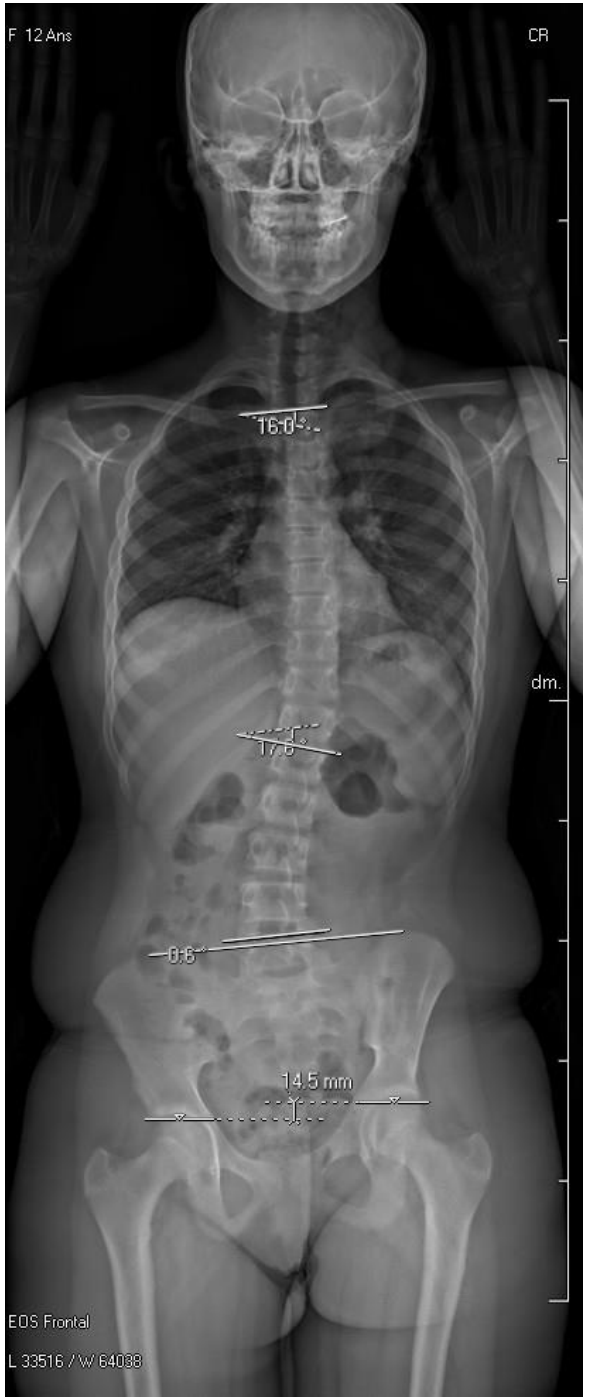
No brace
Physical therapy PSSE 2x / week
Asymetric soles : left IA higher 15, right IA 10, different densities and left heel pad = 5mm

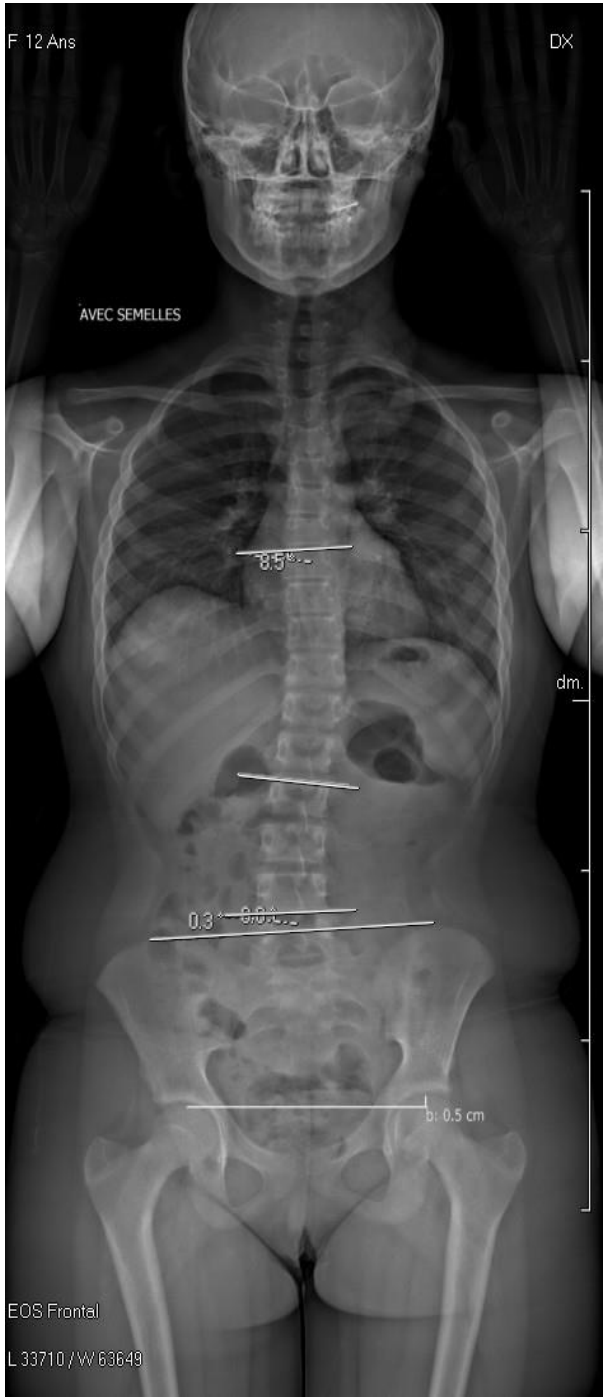
24 months later :
Scoliosis = 11°, spinal tilt in the frontal plane = 0, ATR <5°



Manelle E. 12.5 years old

- Spinal tilt in the frontal plane (measured with a plumb line) = 3 cm to the right
- Valgus flat feet
- EOS without soles: right lumbar Cobb 17°, right pelvic tilt= 14 mm





Manelle E. 12.5 years old

- Spinal tilt in the frontal plane (measured with a plumb line) = 3 cm to the right
- Valgus flat feet
- EOS without soles: right lumbar Cobb 17°, right pelvic tilt= 14 mm

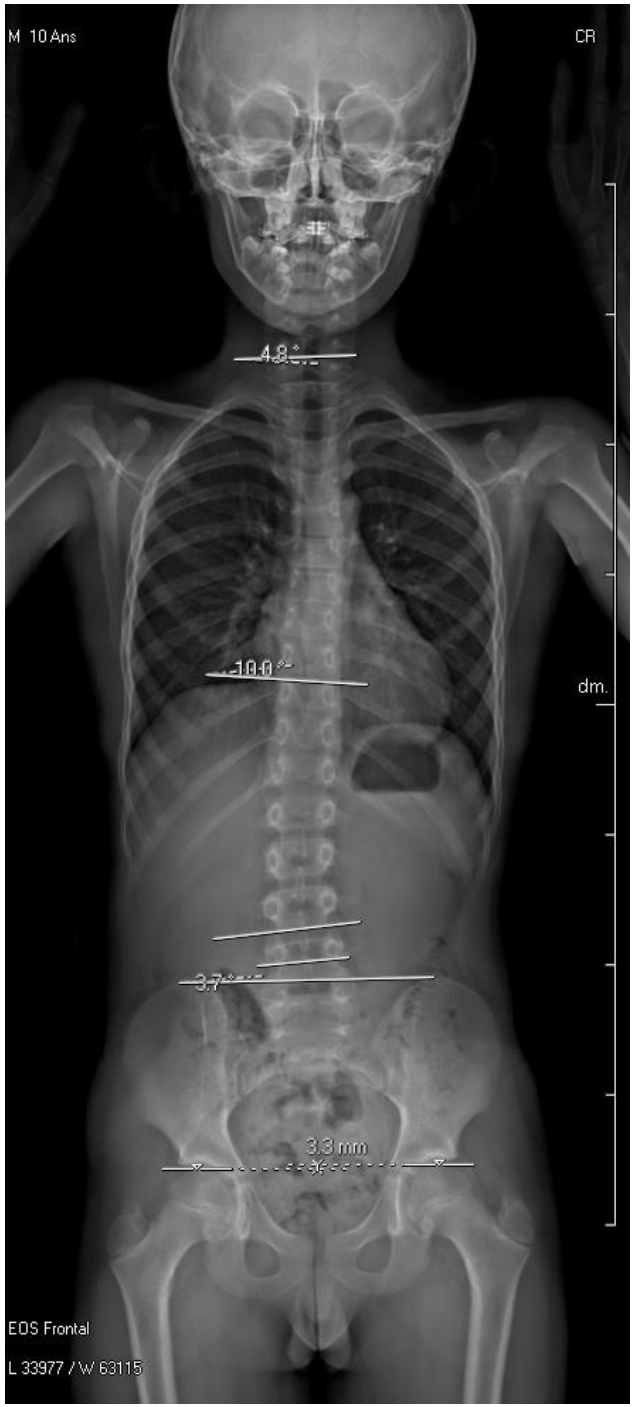
Treatment:

No physiotherapy

Formetric: right compensation 4 + right IA 18 + left IA 15

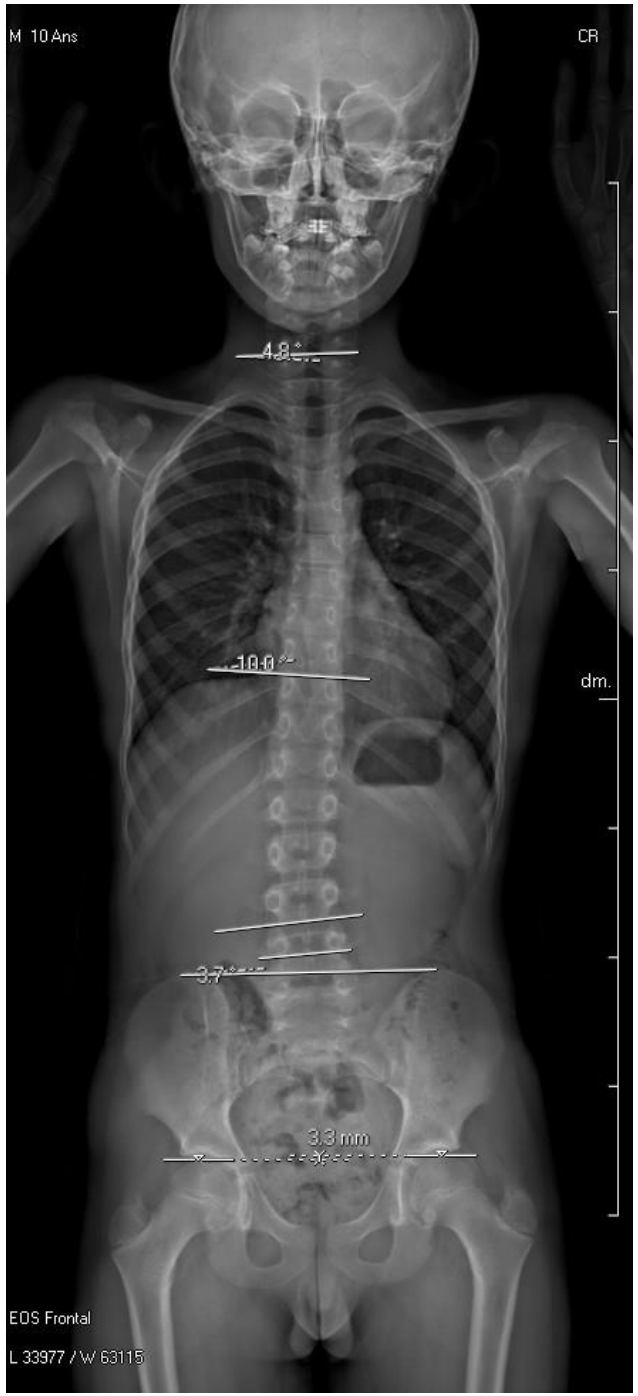
Spinal tilt in the frontal plane (measured with a plumb line) < 1cm to the right

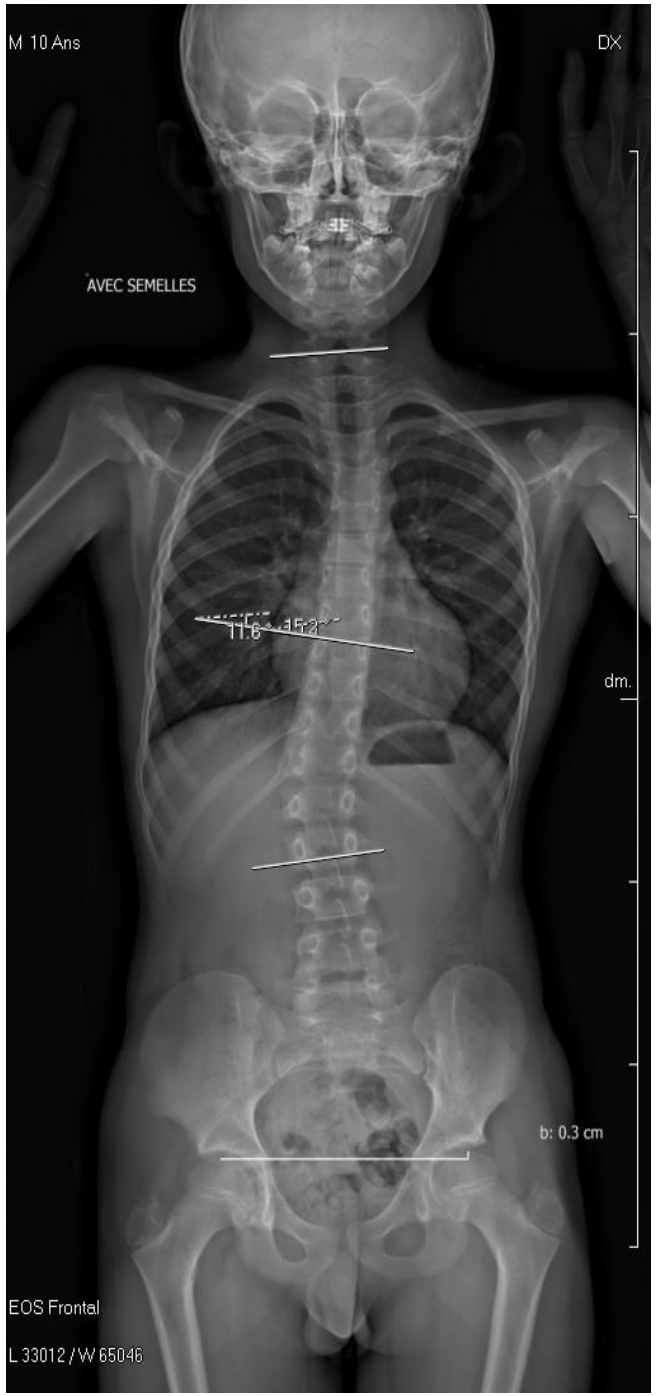
EOS with soles: right lumbar Cobb 8°, right pelvic tilt = 5 mm



Thibaut C. 10 years old

•Spinal tilt in the frontal plane (measured with a plumb line) = 1 cm to the right
•EOS : 2020: right thoracic Cobb 18°, left cervico-thoracic Cobb 6°.
•Physiotherapy, osteopathic treatment, orthoptic rehabilitation
•2021: right thoracic Cobb 16°, left cervico-thoracic Cobb 4°.
•02 2022: right thoracic Cobb 13°, left cervico-thoracic Cobb 4°.
•Orthopaedic soles since 03 2022 at osteopath's request: bilateral ICC=internal calcaneal corner and bilateral ECC=external calcaneal corner.





Thibaut C. 10 years old

Spinal tilt in the frontal plane (measured with a plumb line) = 1 cm to the right

EOS : 2020: right thoracic Cobb 18°, left cervico-thoracic Cobb 6°. Physiotherapy, osteopathic treatment, orthoptic rehabilitation

2021: right thoracic Cobb 16°, left cervico-thoracic Cobb 4°.

02 2022: right thoracic Cobb 13°, left cervico-thoracic Cobb 4°. Orthopaedic soles since 03 2022 at osteopath's request: bilateral ICC=internal calcaneal corner and bilateral ECC=external calcaneal corner

Importance of validating the soles in this case because:

With soles:

Spinal tilt in the frontal plane (measured with a plumb line) = 1,5cm to the right

EOS with soles: right lumbar Cobb 15°, left cervico-thoracic Cobb 11°.

Conclusion:

- These results show the importance of the podiatrist’s role in AIS treatment.
- Asymmetrical soles have an action on reducing the spinal tilt in the frontal plane.
- Our next research work will aim to scientifically validate this type of asymmetrical postural soles to reduce spinal tilt in the frontal plane in AIS but also:
  - for Cobb's angle
  - for pelvic imbalance.

Thank you for your attention !

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