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Chapitre6 Étude de validité

6.1 Article 3 : Validity of a quantitative clinical measurement tool of trunk posture in idiopathic scoliosis

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Sous presse

L'auteur principal confirme sa contribution majeure à l'élaboration du protocole expérimental, au financement du projet, à l'acquisition, au traitement et à l'interprétation des données ainsi qu'à la rédaction de cet article scientifique (90%). Une brève description de la contribution des coauteurs est présentée ci-dessous.

Les docteurs Feldman, Cheriet et Labelle ont dirigé l'étudiante pour la réalisation de cette étude. Dre Feldman a contribué à l'élaboration du protocole expérimental, au financement, à l'analyse des données et à la rédaction de l'article. Dre Cheriet et Dr Labelle ont également contribué à l'élaboration du protocole expérimental et à la rédaction de cet article.

Validity of a quantitative clinical measurement tool of trunk posture in idiopathic scoliosis

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ABSTRACT

Study Design. Concurrent validity between postural indices obtained from digital photographs (2D), surface topography imaging (3D) and radiographs.

Objective. To assess the validity of a quantitative clinical postural assessment tool of the trunk based on photographs (2D) as compared to a surface topography system (3D) as well as spinal indices calculated from radiographs.

Summary of Background Data. To monitor progression of scoliosis or change in posture over time in young persons with idiopathic scoliosis, non invasive and non ionizing methods are recommended. In a clinical setting, posture can be quite easily assessed by calculating key postural indices from photographs.

Methods. Quantitative postural indices of 70 subjects aged 10 to 20 years old with idiopathic scoliosis (Cobb angle: 15º to 60º) were measured from photographs and also from 3D trunk surface images taken in the standing position. Shoulder, scapula, trunk list, pelvis, scoliosis and waist angles indices were calculated with specially designed software. Frontal and sagittal Cobb angles and trunk list were also calculated on radiographs. The Pearson correlation coefficients (r) was used to estimate concurrent validity of the 2D clinical postural tool of the trunk with indices extracted from the 3D system and with those obtained from radiographs.

Results. The correlation between 2D and 3D indices was good to excellent for shoulder, pelvis, trunk list and thoracic scoliosis ($0.81 > r < 0.97$; $p < 0.01$) but fair to moderate for thoracic kyphosis, lumbar lordosis and thoracolumbar or lumbar scoliosis ($0.30 > r < 0.56$; $p < 0.05$). The correlation between 2D and radiograph spinal indices was fair to good (-0.33 to-0.80 with Cobb angles and 0.76 for trunk list; $p < 0.05$).

Conclusion. This tool will facilitate clinical practice by monitoring trunk posture among persons with idiopathic scoliosis. Further, it may contribute to a reduction in the use of x-rays to monitor scoliosis progression.

Keywords: posture, surface topography, validity, idiopathic scoliosis

Key points

1) Development of non invasive methods is recommended to monitor progression of scoliosis or change in posture over time in persons with idiopathic scoliosis.
2) Quantitative assessment of trunk posture from photographs is valid among subjects with idiopathic scoliosis.
3) Measurement of spinal indices such as trunk list and thoracic scoliosis from surface markers may be a clinical alternative to reduce radiograph frequency.
4) This non-invasive tool may facilitate the follow-up of trunk posture and scoliosis progression.

INTRODUCTION

Idiopathic scoliosis (IS) is associated with three-dimensional (3D) morphologic modifications of the trunk which result in postural asymmetries. These asymmetries are associated with the risk of progression of the deformation[1-3] which can affect functional activities[4,5] and limit participation in active life[6]. Correction of posture is thus an important goal of treatment in children and adolescents with IS. To monitor change in scoliosis over time, the Cobb angle remains the gold standard[7]. Calculated from radiographs, it gives information on bony structures or vertebral alignment. The use of non invasive methods to monitor progression of scoliosis or change in posture over time will decrease the risk associated with repeated radiation doses[8-11]. The scoliometer[12-14] is an example of a simple, reliable and non radiating tool that has demonstrated its usefulness in school screening and prediction of scoliosis progression. However, this tool measures rib hump which is only one index of posture. Various 3D posture analysis systems such as Optotrak, Vicon, Motion Analysis and surface topography systems have been used to quantitatively assess posture of subjects with IS[11,15-19]. Among these approaches, surface topography systems appear to be more appropriate to assess trunk postural impairments as they offer a better 3D description of the morphological deformity associated with scoliosis [8,15,16,18]. However, these systems are not accessible for most clinicians since they are expensive, require specialized trained technicians and the data processing is complex. Thus a simpler tool is needed to measure posture quantitatively in a clinical setting and to monitor scoliosis progression. A promising technique to easily assess posture in clinic is based on the calculation of body angles and distances on photographs[20-24]. Photograph acquisition has demonstrated good intra and inter-rater reliability for several postural indices in normal subjects[21-23, 25,26] and subjects with IS[27]. However, the validity of only a few trunk postural indices taken from photographs or surface markers has been assessed[9,23,26,28]. Except for the trunk list index[9,28], the validity of these indices was evaluated among normal persons and not on persons having trunk deformities and were not specific enough to characterize scoliosis progression.

Since postural indices (angles or distances) taken on photographs are in 2D while the postural asymmetries are in 3D, it is important to verify if the 2D indices correlate well with the 3D postural asymmetries. Thus, our objective was to determine the validity of a new quantitative clinical postural assessment tool among subjects with IS. More specifically, we wanted to: 1) verify the concurrent validity of each 2D postural index of the trunk with a 3D surface topography system; 2) evaluate the concurrent validity of the spinal indices in the frontal and sagittal planes with conventional radiographs.

Methods

Participants

Seventy subjects (60 females and 10 males) were recruited from the scoliosis clinic at the Sainte-Justine University Hospital Center in Montreal. Inclusion criteria were: ages 10 to 20 years old, idiopathic scoliosis diagnosis with a frontal deformity between 15º and 60º (Cobb angle) and pain-free at the time of evaluation. Patients who had a leg length discrepancy greater than 1.5 centimetres as well as those who had had spine surgery were excluded. For the radiograph study, 20 subjects were excluded because their X-rays had not been taken within four months of the photographic evaluation. Mean age of participants was 15.7 ± 2.5 years and average weight and height were 51.9 ± 9.3 Kg and 161 ± 9.5 cm, respectively. Twenty-six subjects had a right thoracic scoliosis (mean of 37.9º ± 11.4º), 22 a double major scoliosis (means for each curve of 34.8º ± 13.0º; 33.2º ±11.2º), 16 a thoraco-lumbar scoliosis (mean of 25.8º ± 7.2º) and six a lumbar scoliosis (mean of 26.7º ±13.3º). All subjects and their parents signed informed consent forms and the project was approved by the ethics committee of the Sainte-Justine University Hospital Center.

Procedure

Participants were assessed by a trained physiotherapist at our laboratory at Sainte-Justine University Hospital Center and a quantitative postural evaluation software was used to calculate postural indices of the trunk. The software has a user-friendly graphical interface and it allows calculation of postural indices from a set of markers selected interactively on the digital photographs (Figure 1). These markers (5 mm in diameter) were placed on the subject by the physiotherapist on the spinous processes (C7 to S1), coracoid process, inferior angle of the scapulae, anterior superior iliac spine (ASIS) and posterior superior iliac spine (PSIS). To facilitate measurement of sagittal postural indices, hemispheric 10 mm reflective markers were added on C7, upper end, apex and lower end vertebrae of the thoracic and lumbar spine, ASIS and PSIS. Other anatomical reference points such as upper end, lower end and center of the waist were also used for angle calculation of the right and left waist angle indices.

Our surface acquisition of trunk geometry was achieved with four 3D optical digitizers (3D Capturor, InSpeck Inc., Montreal, Canada). Each digitizer includes a structured light projector and a CCD camera connected to a computer. For the acquisition, the subject stands in erect position in the center of the set-up at an approximate distance of 1.5 m from each digitizer (Figure 2). The four projectors are turned on in succession and project structured light, i.e. a pattern of black and white narrow stripes which is deformed by the trunk's external shape. The fringe pattern is shifted three times, thus each CCD camera captures four fringe images. A fifth image without the fringes, allowing texture mapping on the reconstructed geometry, is also acquired by each camera. The complete process requires around 4 to 6 s [10]. Each digitizer acquires 4 fringe images as well as a texture image using FAPS (Fringes Acquisition and Processing Software, InSpeck Inc.). This device uses Phase-Shifted Moiré projection, an interferometry measurement method and an active optical triangulation technique to reconstruct 3D textured surface models. Spatial relations between the digitizers are established previously by a calibration procedure, in order to allow merging of the 3D polygonal surfaces obtained from the four digitizers. Thus, using this spatial information, EM (Editing and Merging, InSpeck Inc.) software automatically merges the partial views together to create a single 3D model. Textures from the various images are also merged and mapped onto the surface model.

Digital photographs were taken with two Panasonic Lumix cameras (DMC-FX01, 6.3 mega pixels) placed at a distance of 1.59 m for anterior and right lateral views and 1.73 m for posterior and left lateral views at a height of 87.5 cm. Vertical and horizontal level adjustments of the cameras were done with a carpenter level. Placement and instructions given to all subjects concerning the positioning for data collection were standardized. To limit the variability associated with subject's position, two reference frames for feet placement (triangles of 30º) were drawn on the floor for frontal and sagittal views[29]. Subjects were asked to look straight ahead and stand in a normally comfortable position[21,22,29]. Supplementary sagittal photographs were taken with flexed elbows if ASIS were not visible[21,25] and oblique (45º) as proposed by Watson and Mac Donncha [29] to allow better visualisation of markers on the vertebra for thoracic kyphosis and lumbar lordosis measurement.

A complete acquisition took 8 s and consisted of the following sequence: acquisition of trunk with surface topography (four 3D digitizers) and digital photographs of front and back views. The subject was then asked to turn and hemispheric markers were added on anatomical landmarks as previously mentioned. The subject was placed in the lateral position for acquisition of right and left lateral photographs with the digital cameras.

Quantitative postural indices from digital photographs and from 3D trunk surface were calculated with custom software programs allowing the operator to select a specific marker from the graphical interface and to put it directly on the corresponding anatomical landmark on a subject's photograph or surface. Different sets of markers are available according to each view (anterior, posterior or lateral). Following the selection of the markers associated with the calculation of an angle, its value is automatically displayed (Fig 1 and 3). For angle calculation on photographs, the origin of the horizontal and vertical axes is located at the left bottom corner of the image. For calibration, a cube of 15 cm was used. For the computation of postural indices from the 3D surface of the trunk, angle and distance calculations were obtained by performing first an orthogonal projection of each selected marker on the frontal and sagittal planes, then the postural indices were measured in the corresponding planes. The Appendix describes the methods for angle and distance calculations from 2D, radiographs and the 3D trunk surface. Measurements taken on radiographs were the frontal and sagittal Cobb angles and trunk list (C7/S1). One operator was assigned to one type of measurement i.e. 2D, or 3D or radiographs.

Data analysis

Descriptive statistics (mean, standard deviation (SD)) were used to characterize participants and postural indices.

We used Pearson product moment correlation coefficients to estimate concurrent validity of 2D trunk postural indices (photograph) with 3D postural indices (mean of three measurements obtained from the surface topography system). The Pearson product moment correlation coefficients also served to assess correlation between 2D spinal indices and corresponding measurements on radiographs (frontal and sagittal Cobb angles and trunk list). Our interpretation of the coefficients was: <0.25 as little or no relationship; 0.25 to 0.50 as fair; 0.50 to 0.75 as moderate to good; and >0.75 as good to excellent[30]. All calculations were done using SPSS statistical analysis software (version 17.0 for Windows).

RESULTS

Descriptive data

The mean and standard deviation (SD) of each postural index from the 2D and 3D methods are presented in Table 1. Independent t-tests performed on our cohort reveal that the thoracic scoliosis was statistically larger than the thoracolumbar or lumbar scoliosis as measured by the 2D tool (p=0.001) and the 3D system (p=0.004).

Concurrent validity of postural indices with 3D system

The Pearson product moment coefficients for each postural index ranged from 0.30 to 0.97 and were all statistically significant (Table 1). The level of correlation between the 2D and 3D indices was good for ten indices (r ranging from 0.81 to 0.97) with the highest value for the scapula asymmetry index. The lumbar lordosis, thoracic kyphosis and thoracolumbar or lumbar scoliosis 2D indices are fairly to moderately correlated with the 3D indices (r ranging from 0.30 to 0.56).

Concurrent validity of spinal indices with X-rays

The Pearson product moment coefficients for each spinal index were all statistically significant (Table 2). There were good negative correlations between 2D and X-ray spinal indices for thoracic scoliosis and thoracic kyphosis and good correlation for trunk list. Correlations were fair for lumbar lordosis and thoracolumbar or lumbar scoliosis.

Trunk list, thoracic scoliosis and thoracolumbar or lumbar scoliosis demonstrated a higher degree of correlation with the 3D system whereas thoracic kyphosis and lumbar lordosis were more highly correlated with the Cobb angle measurement method.

DISCUSSION

To our knowledge, this study is the first to assess the validity of a quantitative clinical postural assessment tool of the trunk among subjects with IS, using photographs, a 3D system and radiographs. Surface topography systems have been largely used in research to characterise the 3D morphology of persons with IS [8,15-19]. These systems have adequate accuracy (mean errors for all markers: 1.1 ± 0.9 mm), good correlations with Cobb angle for several indices of the trunk, an excellent inter-trial level of reliability (ICCs ≥ 0.91) and a short acquisition time (5 s) [10,15,16,18].

Our results show a good to excellent correlation between 2D postural indices from photographs and postural indices obtained from 3D trunk surface for indices representing shoulder, pelvis, trunk alignment and thoracic scoliosis angle. Correlation was only fair to moderate for the thoracic kyphosis, lumbar lordosis and thoracolumbar or lumbar scoliosis spinal indices. For thoracolumbar or lumbar scoliosis index, the low correlation may be attributable to differences in the selection of the vertebrae for this calculation. Two different technicians performed the 2D photographs and 3D surface measurements. According to Mior et al. [31] and Cheung et al. [32], the inter-rater reliability for identification of upper end, apex and lower end vertebra is higher on the larger curve. Thoracolumbar or lumbar scoliosis curves were smaller than the thoracic scoliosis ones. As for Cobb angle measurement on x-rays, it is recommended that the same person perform the vertebrae selection for scoliosis calculation. Also, the line segments used in the calculation of the lumbar scoliosis are shorter. Thus, a small deviation in marker placement from shorter line segments will produce a larger difference in angle calculation as compared with longer ones.

The low relationship between 2D and 3D measurements for sagittal spinal curves may arise from the oblique (45º) position in which the measurements were taken. Because of the trunk asymmetry, reflective markers were not always visible on sagittal views. The relationship between these 2D sagittal spinal indices was higher with the Cobb angle, in agreement with the results of Raine and Twomey [23]. Even though the thoracic kyphosis has demonstrated a good negative relationship with the sagittal Cobb angle, the results with the 3D system suggest that oblique measurements are not representative of the 3D thoracic kyphosis and lumbar lordosis. Van Niekerck et al.[26] proposed a technique using sticks with reflective markers and showed good correlation (r=0.81) between photo and X-rays for the thoracic kyphosis taken in upright sitting position among normal youths. This may be a more appropriate way to assess sagittal spinal curves on photographs, but will need to be verified in the standing position among subjects with IS.

Except for the thoracic kyphosis and lumbar lordosis, 2D spinal indices had higher correlation with the 3D system than with X-ray measurements. This could be attributable to the fact that 2D and 3D measurements were calculated from the same markers, were done in the same position, and only a few seconds apart whereas radiographs were taken in a different position, and not necessarily on the same day. As demonstrated by Engsberg et al.[9] and Lenke et al.,[28] for trunk list measurement, the relationship between measurement from surface markers and anatomical landmarks on radiographs was strong only when taken simultaneously. For thoracic scoliosis and thoracolumbar or lumbar scoliosis indices, measurements on photographs derive from markers placed on spinous processes whereas measurements on radiographs were determined by the Cobb angle technique. The curve described by the spinous processes underestimated the magnitude of scoliosis[33] and is more influenced by the rotation of the apical vertebra[34]. According to our results, it seems that the correlation between surface markers and identified vertebral bodies on X-ray is better for C7 and the thoracic region than for the lumbar region.

The main limitations of this study are related to the time lapse between photograph and radiograph acquisitions and to the differences in upper end, apex and lower end vertebrae selection for the calculation of scoliosis angles from photographs, 3D surface topography system and radiographs. The acquisition of a low-dose radiograph device (EOS system) by the hospital will facilitate the realisation of future studies where the concordance of surface reflective markers placed on the trunk can be assessed against the real position of the vertebrae.

This non-invasive tool should be easy to use in a clinical setting to monitor trunk posture as both the digital camera and the software are inexpensive, the graphical interface of the software is user-friendly (two hours of training were enough to achieve reliable measurements) and the time required to complete a trunk evaluation is about 20 minutes (10 minutes for marker placement and photograph acquisitions and 10 minutes for angles and distances calculation with the software). Some indices such as waist angles, trunk list and thoracic scoliosis are good indices to characterize scoliosis and present a good relationship with the 3D system or with both, the 3D system and X-rays. In a previous study, we found an excellent level of inter-occasion and inter-rater reliability for these indices [27]. The good validity and the excellent reliability of these clinical indices taken from photographs, in combination with the scoliometer, may support their use as a good alternative for scoliosis screening, to reduce the number of radiographs for the monitoring of scoliosis progression and to document cosmetic changes after conservative or surgical treatment.

Conclusion

The good to excellent correlations between measurements taken on photographs and those obtained from the 3D surface topography system found in this study suggest that 10 out of 13 postural indices of the quantitative clinical postural assessment tool of the trunk are valid. Trunk list and thoracic scoliosis indices measured from surface markers on photographs are sufficiently well correlated with measurements on radiographs to be considered as an alternative to monitor scoliosis progression in a clinical setting. This tool will facilitate clinical practice by monitoring trunk posture and may contribute to a reduction in the use of x-rays among persons with IS. However, future studies are still needed to demonstrate if postural indices included in this tool are sensitive enough to detect scoliosis progression or treatment effectiveness.

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APPENDIX

Postural indices of the trunk and methods of angle and distance calculation on 2D, 3D and X-ray

Postural indices of the trunk	**Body angle and distance calculation 2D/3D and X-ray***
1. Shoulder Elevation	A line drawn between the left and right coracoid process markers, and the angle of this line to the horizontal.
2. Scapula Asymmetry	The angle formed by a line drawn from the left and right inferior angle of scapula and the horizontal.
3. Waist Angle R 4. Waist Angle L	The angle subtended by lines drawn through the upper end of waist to the center of waist and the center of waist through the lower end of waist.
5. Trunk List	Distance between a line from C7 to S1. *X-ray: distance between a line from the center of vertebral body of C7 to the center of vertebral body of S1.
6. Thoracic scoliosis (modified Ferguson angle) 7. Thoracolumbar or lumbar scoliosis (modified Ferguson angle)	The angle subtended by lines drawn through the upper end-vertebra of the curve to the apex of the thoracic/thoraco-lumbar/lumbar scoliosis and the apex through the lower end-vertebra of the curve. *X-ray: Frontal Cobb angle.
8. Thoracic kyphosis	The angle subtended by lines drawn through the upper end-vertebra of the curve to the apex of the kyphosis and the apex through the lower end-vertebra of the curve. *X-ray: Sagittal thoracic Cobb angle.
9. Lumbar Lordosis	The angle subtended by lines drawn through the upper end-vertebra of the curve to the apex of the lordosis and the apex through L5. *X-ray: Sagittal lumbar Cobb angle.
10. Frontal Pelvic tilt (front) 11. Frontal Pelvic tilt (back)	The angle subtended by the horizontal and by the line joining the two ASIS (front) and the two PSIS (back).
12. Sagittal Pelvic tilt R 13. Sagittal Pelvic tilt L	The angle subtended by the horizontal and by the line joining the PSIS and ASIS.

Figure legends

Figure 1

Graphical interface with a reduced set of markers of the quantitative postural assessment tool at the left and a numerical photograph of a subject at the right. The green circles can be individually displaced by the operator for the calculation of 2D postural indices. The six figures represent the scapula asymmetry, the thoracic scoliosis, the right and left waist angles, the trunk list distance and the frontal pelvic tilt.

Figure 2

Trunk surface topography measurement and reconstruction. **A)** Experimental set-up with four Capturor InSpeck optical digitizers. **B)** Example of a Capturor 3D optical digitizer, consisting of a CCD camera coupled with a structured light projector. **C)** Set of four fringe images, each offset by ¼ phase, projected by a digitizer onto the back of a torso manikin. The fifth image provided the surface texture. **D)** Resulting phase image from the four fringe images; surface reconstruction uses the interferometry principle combined with active triangulation. **E)** The process of registering and merging the partial surfaces from the different digitizers produces the complete trunk surface.

Figure 3

Graphical interface for the trunk surface reconstruction (left panel) with all the tools available for the calculation of 3D postural indices (right panel). The red bars and lines represent different angles and distances calculated and displayed in the right panel.

Table 1. Means and standard deviations (SD) of 2D and 3D indices and concurrent validity (r) of 2D with 3D postural indices of the trunk

Postural Indices (N)	Mean (SD) (º or mm*) 2D	3D	Validity (r) 2D with 3D
Shoulder elevation (68)	-2.1 (3.9)	-0.9 (3.0)	0.88
Scapula asymmetry (68)	-4.3 (7.3)	-3.2 (6.1)	0.97
Waist angle (left) (68)	154.8 (9.9)	154.8 (10.6)	0.82
Waist angle (right) (68)	152.8 (10.0)	149.9 (12.5)	0.87
Thoracic scoliosis (59)	163.0 (8.3)	162.0 (7.7)	0.83
Thoracolumbar or lumbar scoliosis (51)	168.3 (6.5)	166.0 (6.3)	0.56
Thoracic kyphosis (61)	166.0 (8.5)	166.0 (5.8)	0.35
Lumbar Lordosis (59)	161.9 (7.8)	169.3 (7.7)	0.30†
Trunk list (68)	8.8 (19.4)*	9.6 (16.6)*	0.89
Pelvic frontal tilt (face) (69)	-1.5 (2.2)	-1.1 (2.0)	0.81
Pelvic frontal tilt (back) (68)	-1.6 (3.5)	-1.4 (3.2)	0.90
Pelvic sagittal tilt (left) (62)	11.3 (5.3)	12.9 (4.9)	0.87
Pelvic sagittal tilt (right) (58)	12.5 (5.5)	13.0 (5.1)	0.89

Legend: *Data is in mm.

All correlations were statistically significant $p < 0.01$, except †: $p < 0.05$

Table 2. Means and standard deviations (SD) of X-Ray measurements and concurrent validity of 2D postural indices with X-Ray measurements for each spinal index

Spinal Indices (N)	Mean (SD) (º or mm*) 2D	X-Rays	Validity (r) 2D with X-Rays
Thoracic Scoliosis (37)	163 (9)	34 (13)	-0.80
Thoracolumbar or lumbar scoliosis (36)	168 (7)	30 (10)	-0.33
Thoracic kyphosis (40)	167 (8)	27 (11)	-0.77
Lumbar lordosis (44)	163 (8)	46 (11)	-0.48
Trunk list (50)	11.4 (19.7)*	5.0 (18.2)*	0.76

Legend: *Data is in mm.

All correlations were statistically significant $p < 0.01$

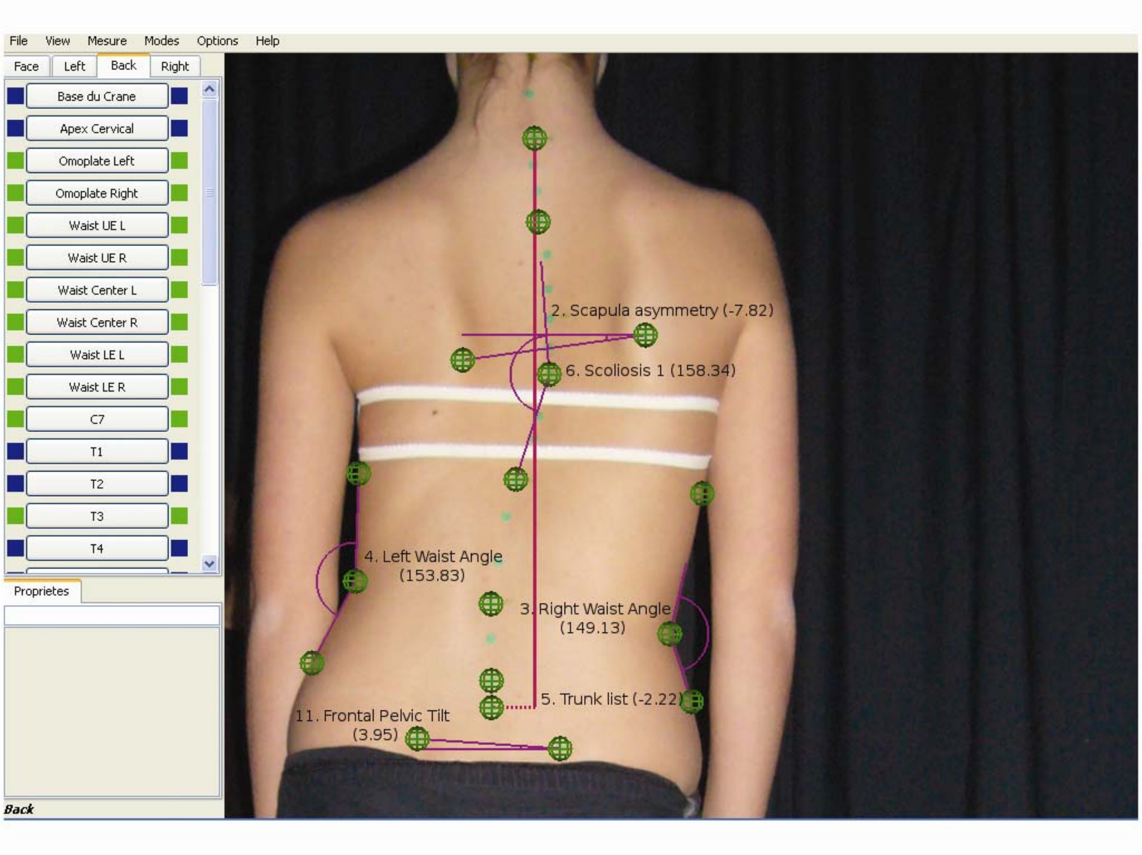

File
View
Mesure
Modes
Options
Help
Face
Left
Back
Right
Base du Crane
Apex Cervical
Omoplate Left
Omoplate Right
Waist UE L
Waist UE R
Waist Center L
Waist Center R
Waist LE L
Waist LE R
C7
T1
T2
T3
T4
Proprietes
Back
2. Scapula asymmetry (-7.82)
6. Scoliosis 1 (158.34)
4. Left Waist Angle
(153.83)
3. Right Waist Angle
(149.13)
5. Trunk list (-2.22)
11. Frontal Pelvic Tilt
(3.95)

Figure 1

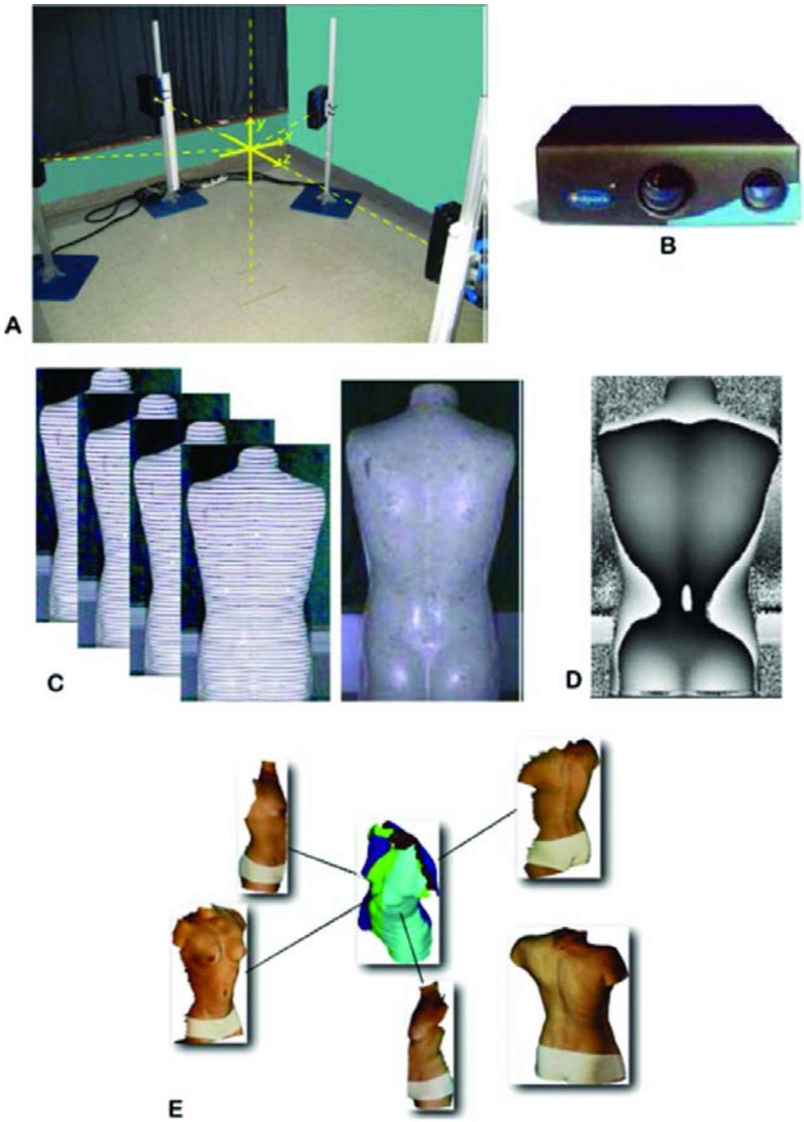
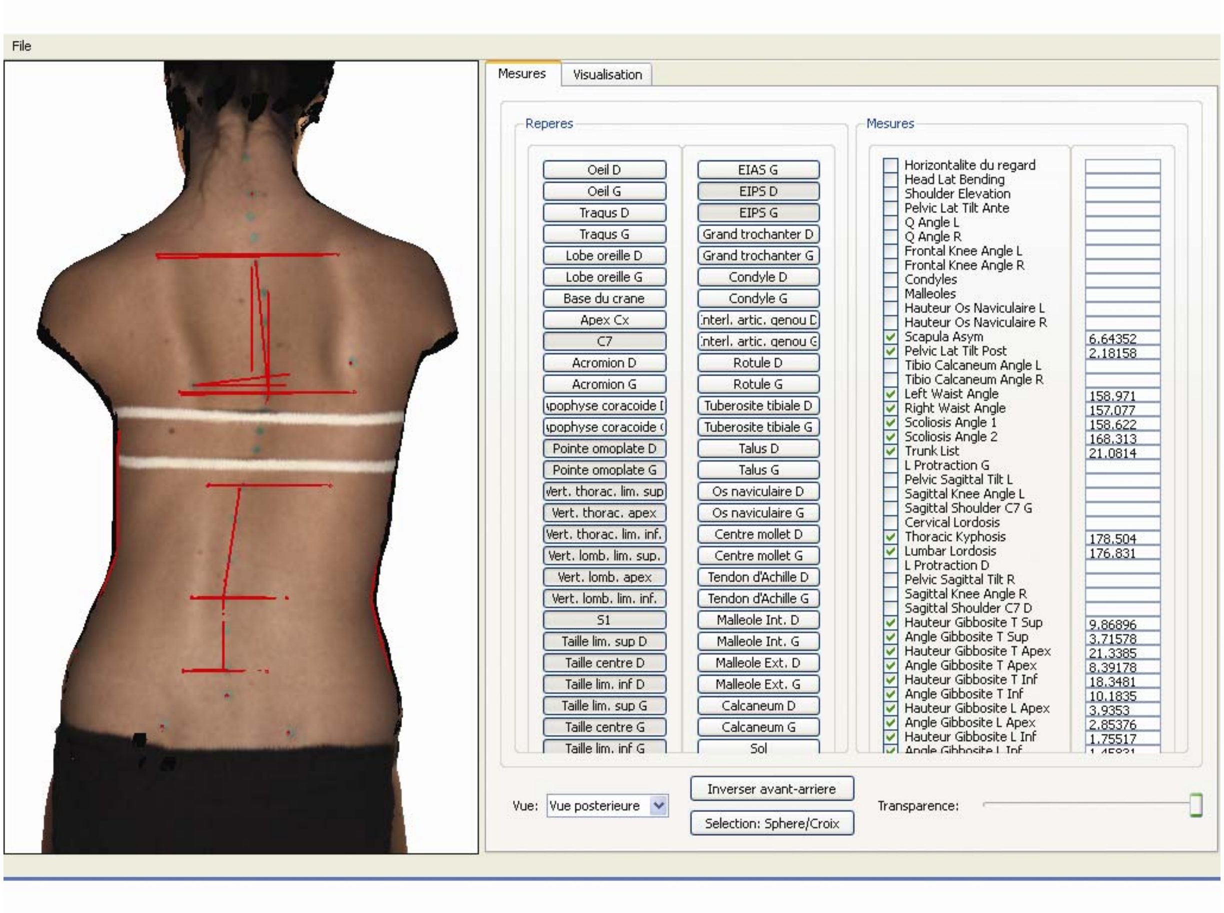


Figure 2



Mesures

☐ Horizontalite du regard	
☐ Head Lat Bending	
☐ Shoulder Elevation	
☐ Pelvic Lat Tilt Ante	
☐ Q Angle L	
☐ Q Angle R	
☐ Frontal Knee Angle L	
☐ Frontal Knee Angle R	
☐ Condyles	
☐ Malleoles	
☐ Hauteur Os Naviculaire L	
☐ Hauteur Os Naviculaire R	
☑ Scapula Asym	6.64352
☑ Pelvic Lat Tilt Post	2.18158
☐ Tibio Calcaneum Angle L	
☐ Tibio Calcaneum Angle R	
☑ Left Waist Angle	158.971
☑ Right Waist Angle	157.077
☑ Scoliosis Angle 1	158.622
☑ Scoliosis Angle 2	168.313
☑ Trunk List	21.0814
☐ L Protraction G	
☐ Pelvic Sagittal Tilt L	
☐ Sagittal Knee Angle L	
☐ Sagittal Shoulder C7 G	
☐ Cervical Lordosis	
☑ Thoracic Kyphosis	178.504
☑ Lumbar Lordosis	176.831
☐ L Protraction D	
☐ Pelvic Sagittal Tilt R	
☐ Sagittal Knee Angle R	
☐ Sagittal Shoulder C7 D	
☑ Hauteur Gibbosite T Sup	9.86896
☑ Angle Gibbosite T Sup	3.71578
☑ Hauteur Gibbosite T Apex	21.3385
☑ Angle Gibbosite T Apex	8.39178
☑ Hauteur Gibbosite T Inf	18.3481
☑ Angle Gibbosite T Inf	10.1835
☑ Hauteur Gibbosite L Apex	3.9353
☑ Angle Gibbosite L Apex	2.85376
☑ Hauteur Gibbosite L Inf	1.75517
☑ Angle Gibbosite L Inf	1.45831

Vue: Vue posterieure

Figure 3