Introduction:
Adolescent idiopathic scoliosis (AIS) is a 3D deformity of the spine, the severity of which is quantified by the Cobb angle (Fig.1a). A major issue in the treatment of AIS is the need of monitoring curve progression with frequent radiological (RAD) examinations. Although a lower-dose solution (the EOS system) has been developed to limit the radiological exposure, methods based on rasterstereography (RST) of the back surface have been evaluated as non-invasive alternative, but were found as not sufficiently accurate [1,2]. In the last years, an increasing number of studies have applied Artificial Intelligence techniques to predict parameters from biomedical images in spine research [3]. As novel application, the present study exploits a machine learning application based on convolutional neural networks to predict the Cobb angle from RST image in AIS.
Methods:
A dataset of 149 AIS subjects acquired in a previous study [1] (age ranging from 10 to 17 years, mean(SD)=13(3)) with Cobb angle ranging from 1° to 45° (mean 23°(11°)) undergone RAD by EOS system and RST (by Formetric4D device) in the same session was exploited (Fig.1a,b). The Cobb angle measured on RAD (the largest in case of more than one curve) was used as ground truth information. Training- and test-set of RST images (110 and 39 subjects, respectively) were randomly defined. Pre-trained neural network for image classification (ResNet18) from ImageNet was exploited. Final classification layer was removed, obtaining the prediction of the Cobb angle as output of final regression layer. Image processing accounted for the following sequence of operations: cropping and resizing to 224x224 pixel (Fig.1b,c); data augmentation (x8) by randomly applying one or more manipulations among rotation, reflection, contrast/brightness adjustment, and zoom in/out (Fig.1c). Final augmented training-set of 880 images was obtained. The net was retrained (fine-tuning) by progressively unfreezing the weights of the deepest layers up to half of net length, in consecutive steps with increasing number of epochs. The test-set was processed with the retrained net to obtain the predicted Cobb angle.
Results:
Mean(SD) value of prediction error was 7°(5°). Accuracy (percentage of cases with prediction error < 7°) was 0.64. Correlation coefficient between true and predicted Cobb angle was 0.41. In general, the difference between measures was lower than 10° (Fig.1c).
Discussion:
Processing the RST image of the back surface by machine learning approach provided moderate accuracy in predicting the Cobb angle, with moderate correlation between predicted and true value. Overall, that application does not represent an advance for considering RST as a valid non-invasive alternative to RAD. Such results can be mostly related to the small sample size, and larger datasets should be accounted for to improve the performance of the net and better investigate the application to RST.

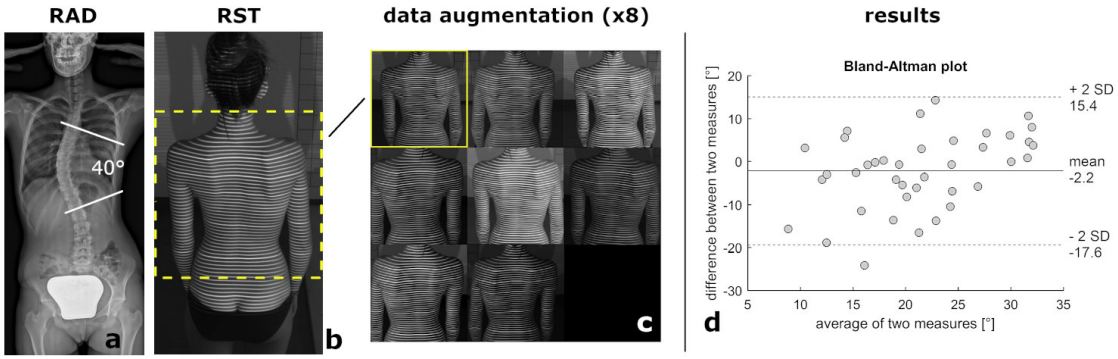

Figure 1: Radiographic (a) and rasterstereographic (b) image of one subject, and example of data augmentation (c) from cropped and resized section. Right panel (d): Bland-Altman plot for true and predicted Cobb angle.