

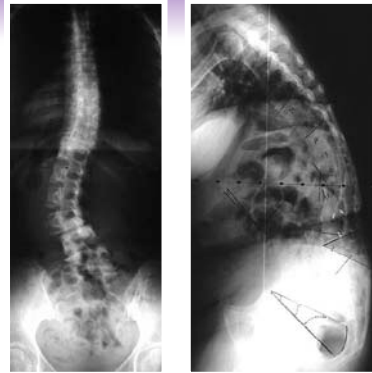
QUANTITATIVE ANALYSIS OF KEY MUSCLES OF THE THORACO LUMBAR SPINO-PELVIC COMPLEX: 3D GEOMETRY AND HOMOGENEITY

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Blondel B	NA
Jolivet E	NA
Lafage V	Nemaris, Shareholder
Skalli W	NA

Clinical practice for
Adult with spinal
deformity =



X ray analysis

Limited Investigation in
Muscular system

No relevant Tool

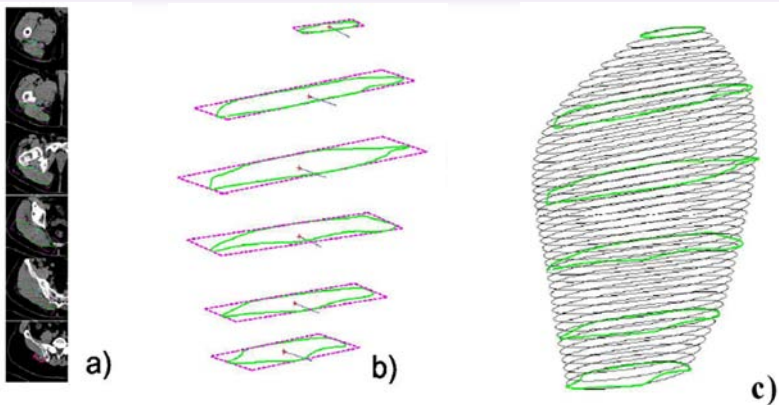
⊙ **Relevant tool :3 conditions**

- ⊙ Global analysis
- ⊙ Time consuming
- ⊙ Fat infiltration



DPSO Methods
(research relevant)
Jolivet et al 2007

??????????????



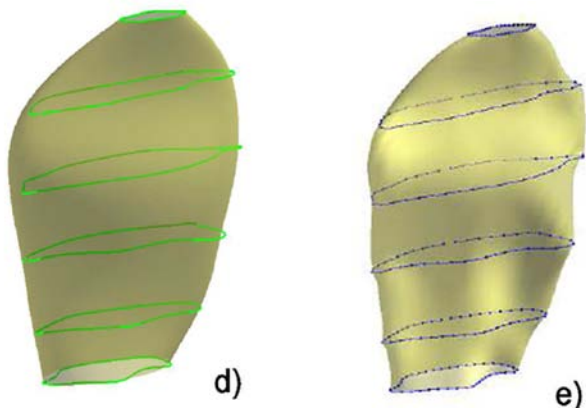
A: Sub-set of MRI axial slices were manually segmented (MSS: manually segmented slices). Using contrast differences, these manual segmentations were then optimized

B: Contours approximated by ellipses

C: Cubic spline interpolation was used to interpolate ellipses in all non-outlined slices covering the muscle

D: Interpolated ellipses generated a 3D parametric object

E: Kriging algorithm, the parametric object was deformed non-linearly using the manual segmentations of MSS as control points



+ Contrast enhancements, Geometry-correction algorithm, Visual verification/Correction

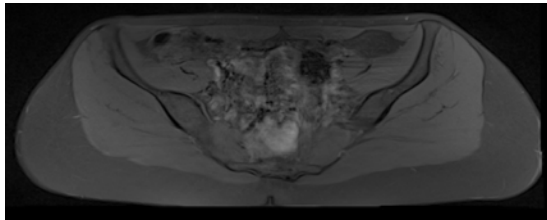
⊙ CT scan : [Jolivet 2007,2009]

- ⊙ + Good contrast: Fat / Muscles
- ⊙ + Good reliability: Fat / Muscle density
- ⊙ - Radiation

⊙ MRI: T1 sequence [Sudhoff 2009]

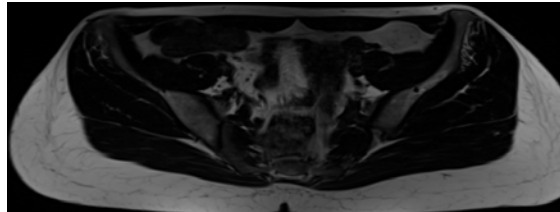
- ⊙ + Good contrast: Fat / Muscles
- ⊙ - Poor reliability: Fat / Muscle density

→ Proposed Sequence : MRI Three point Dixon methods [Glover and Schneider, 1991]



Water image

+



Fat image

→

$$100x \frac{\text{Fat-Water}}{\text{Fat + Water}}$$

= Image Fat/Water

Validation and reproducibility of the DPSO method with three point Dixon images

⊙ Protocol

- ⊙ Two volunteers (axial slices, 5mm, knee to T12)
- ⊙ Two acquisitions : T1 sequence + Three point Dixon
- ⊙ 36 muscles (18 right /18 left)

⊙ Reference Methods :

- ⊙ Segmentation: all T1 slices

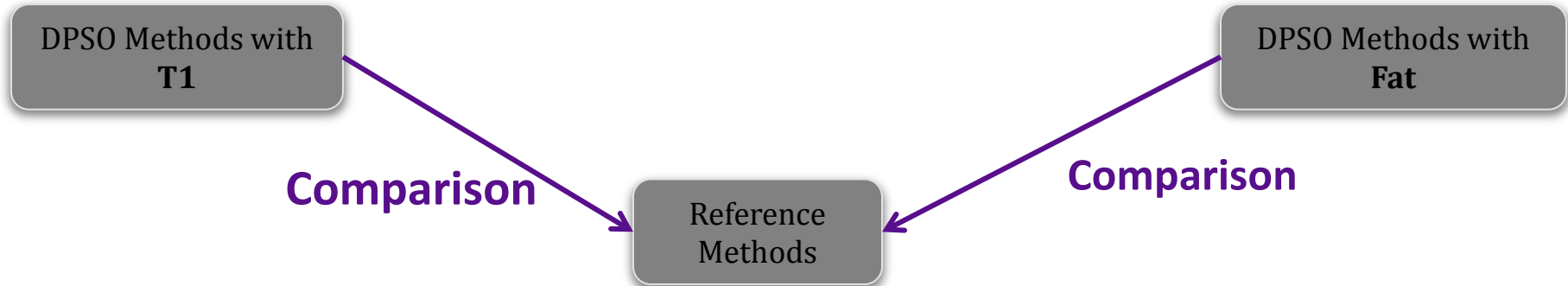
⊙ Reproducibility : Parameters of interest of the reconstructions

- ⊙ Maximal section , mean section , length , volume, fat infiltration
- ⊙ Shape

Muscles reconstructed (R/L)
Adductor
Biceps femoris
Erector spinae
Gluteus maximus/ medius/minimum
Gracilis
Iliacus
Obliquus
Psoas
Quadratus lumborum
Rectus abdominus
Rectus femoris
Sartorius
Semi membranous tendinitis
Tensor Fascia Lata
Vastus lateralis inter
Vastus medialis

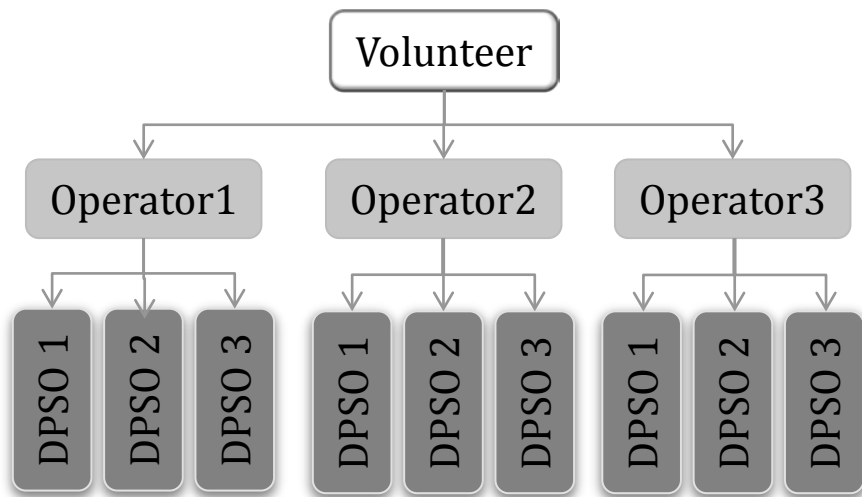
Agreement between methods (1 Operator)

Percentage of difference between methods for maximal section, mean section, length, and volume.



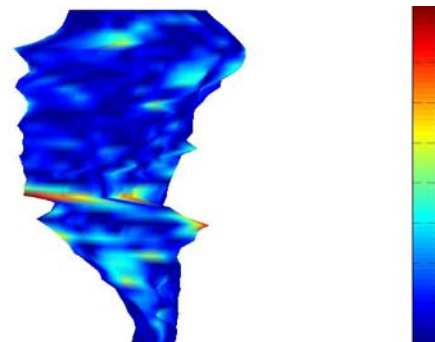
Intra and Inter variability (Fat & T1)

- 3 operators , 3 sessions
- maximal section, mean section, length, volume, Fat infiltration (Only Fat images)



Shape reproducibility (Fat & T1)

- Projection on reference
- Distance point to surface



Comparison bet. reproducibility

RESULT : AGREEMENT IN %

on all the muscles and both volunteers	(Reference Method – DSPO Method)/ Reference Method for one operator and both volunteers							
	Max Section		Mean Section*		Length		Volume*	
	T1	FAT	T1	FAT	T1	FAT	T1	FAT
Mean	1.21	1.16	0.74	2.20	0.91	0.44	1.10	2.19
Std	4.87	6.17	2.57	2.82	1.79	2.44	2.50	2.85
Limits of agreement sup (Mean+2xStd)	10.95	13.49	5.87	7.84	4.49	5.32	6.10	7.89
Limits of agreement inf (Mean-2xStd)	-8.53	-11.18	-4.39	-3.45	-2.68	-4.45	-3.91	-3.50
Max	15.43	15.57	6.01	6.92	6.18	10.39	5.92	6.92
Min	-9.41	-17.75	-6.22	-6.50	-2.96	-4.08	-6.62	-6.46

- ⊙ The agreement between the DSPO method with T1 images and the Reference Method was better than the agreement between the DSPO method with Fat images and the Reference for the volume and the mean section
- ⊙ On average, the DSPO method compared to the Reference Method, tended to underestimate all parameters. (~1-2 %)
- ⊙ For both sequences the maximal section had the largest errors.

RESULT : INTRA-INTER VARIABILITY IN %

Intra –Variability (coefficient of variance)

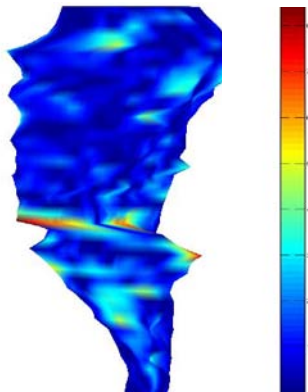
	Max Section		Mean Section		Length*		Volume		Fat_ %
	T1	FAT	T1	FAT	T1	FAT	T1	FAT	FAT
Mean	4.08	3.76	2.16	2.05	1.78	1.26	2.16	2.05	2.23
Std	2.54	2.19	0.87	1.02	2.05	1.02	0.86	1.01	1.25
Max	12.49	10.66	3.81	5.60	9.93	5.16	3.75	5.62	5.56
Min	0.93	1.44	0.94	0.89	0.17	0.10	0.95	0.90	0.82

Inter –Variability (coefficient of variance)

	Max Section		Mean Section		Length*		Volume		Fat_ %
	T1	FAT	T1	FAT	T1	FAT	T1	FAT	FAT
Mean	4.63	4.50	2.56	2.61	1.86	1.42	2.55	2.61	2.98
Std	3.12	3.33	1.09	1.82	2.10	1.27	1.07	1.82	1.76
Max	15.65	19.62	5.80	11.67	9.93	5.93	5.78	11.80	10.59
Min	1.01	1.46	0.94	0.93	0.17	0.14	0.95	0.93	1.24

- © On average, the intra- and inter-operator variability was less than 5% for all the parameters
- © Except for the length, no significant differences were found between T1 and Fat reconstructions in terms of intra- or inter-variability.

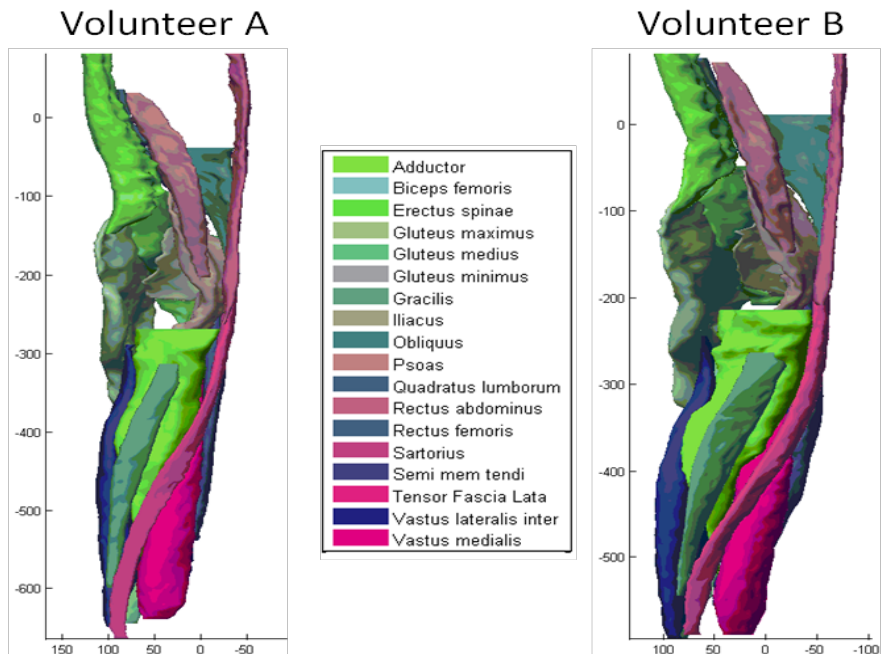
RESULTS: SHAPE REPRODUCIBILITY



	Projection : distance points surfaces in mm							
	Mean 2xRMS *		Std 2xRMS		Min 2xRMS *		Max 2xRMS	
	T1	Fat	T1	Fat	T1	Fat	T1	Fat
Mean	2.62	2.95	0.48	0.52	1.96	2.36	3.80	4.30
Std	0.73	0.91	0.35	0.53	0.57	0.63	1.85	2.72
Min	1.27	1.32	0.16	0.09	0.88	1.15	1.83	1.57
Max	4.15	5.80	1.98	2.91	3.24	3.76	11.30	16.41

- © The mean 2xRMS values were less than 3 with significantly smaller values for the T1 reconstructions than for the fat reconstructions
- © The maximal 2xRMS in terms of point-to-surface-distance for the T1 reconstructions was (11.30 mmn) than for the Fat reconstructions (16.41mm).
- © Smaller error for T1 reconstruction compare to Fat reconstruction

DPSO Methods and Three point Dixon methods



Reconstruction both volunteers (left muscles)

- ⊙ **Substantial reduction in time**
 - ⊙ DPSO methods = 2.5 hours
 - ⊙ Reference methods= 9 hours
- ⊙ **Good Agreement between the methods:**
 - ⊙ Variability between the muscles
- ⊙ **Shape reproducibility mean < 3mm**
 - ⊙ Relative great error maximal
 - ⊙ Muscle poorly approximated by ellipse
 - ⊙ Abrupt variation in the shape between adjacent slices
 - ⊙ Reference was done with T1 images (explain why less reproducibility with fat image)
- ⊙ **Intra-Inter variability < 5 %**
 - ⊙ Variability between muscles
 - ⊙ Distinction between muscles not always straightforward
 - ⊙ Free breathing
- ⊙ **Evaluation of the Fat infiltration**