Classification of pediatric lumbosacral spondylolisthesis

The importance of sagittal balance

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SCOLIOSIS RESEARCH SOCIETY
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Classification of spondylolisthesis

Wiltse and Newman

"Radiological" classification

No help for treatment…

Type I – Dysplastic

Type II – Isthmic

- IIA – Fatigue pars fracture
- IIB – Pars elongation
- IIC – Acute pars fracture

Type III – Degenerative

Type IV – Traumatic (other than pars)

Type V – Pathologic

Classification of spondylolisthesis

Marchetti and Bartolozzi

"Etiological" classification

No quantitative criteria…

Developmental	Acquired
High dysplastic	Traumatic
With spondylolysis	Acute fracture
With elongated pars	Stress fracture
Low dysplastic	Postsurgical
With spondylolysis	Direct surgery
With elongated pars	Indirect surgery
	Pathologic
	Local
	Systemic
	Degenerative
	Primary
	Secondary

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REVIEW

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A proposal for a surgical classification of pediatric lumbosacral spondylolisthesis based on current literature

Table 1 Surgical classification of L5–S1 spondylolisthesis in children and adolescents

Grade of slip[a]	Degree of dysplasia[b]	Sagittal spinopelvic balance[b]	Suggested treatment
Low-grade (0, 1, or 2)	Low-dysplastic	Low PI/low SS (nutcracker type)	Pars repair (grade 0 or 1) versus in situ L5–S1 PLF ± instrumentation ± reduction[c] for grade 2
		High PI/high SS (shear type)	In situ L5–S1 PLF ± instrumentation ± reduction[c] for grade 2
	High-dysplastic	Low PI/low SS (nutcracker type)	In situ L5–S1 PLF & instrumentation ± reduction[c] for grade 2
		High PI/high SS (shear type)	In situ L5–S1 PLF & instrumentation ± L4 & pelvic fixation ± reduction[c] for grade 2
High-grade (3 or 4)	Low-dysplastic	High SS/low PT (balanced pelvis)	In situ L4-S1 PLF & instrumentation ± pelvic fixation ± partial reduction[c]
		Low SS/high PT (retroverted pelvis)	Partial reduction & L4-S1-pelvic instrumentation & PLF ± L5–S1 IF
	High-dysplastic	High SS/low PT (balanced pelvis)	Partial reduction & L4-S1-pelvic instrumentation & PLF ± L5–S1 IF
		Low SS/high PT (retroverted pelvis)	Partial reduction & L4-S1-pelvic instrumentation & PLF & L5–S1 IF
Spondyloptosis	High-dysplastic		Circumferential fusion, instrumentation, with or without reduction

Rationale of the classification

- Significant influence of slip percentage (Low-grade vs. High-grade)
  - Important prognostic factor
  - Influences treatment outcome (bracing and surgery)
  - Related to HRQOL

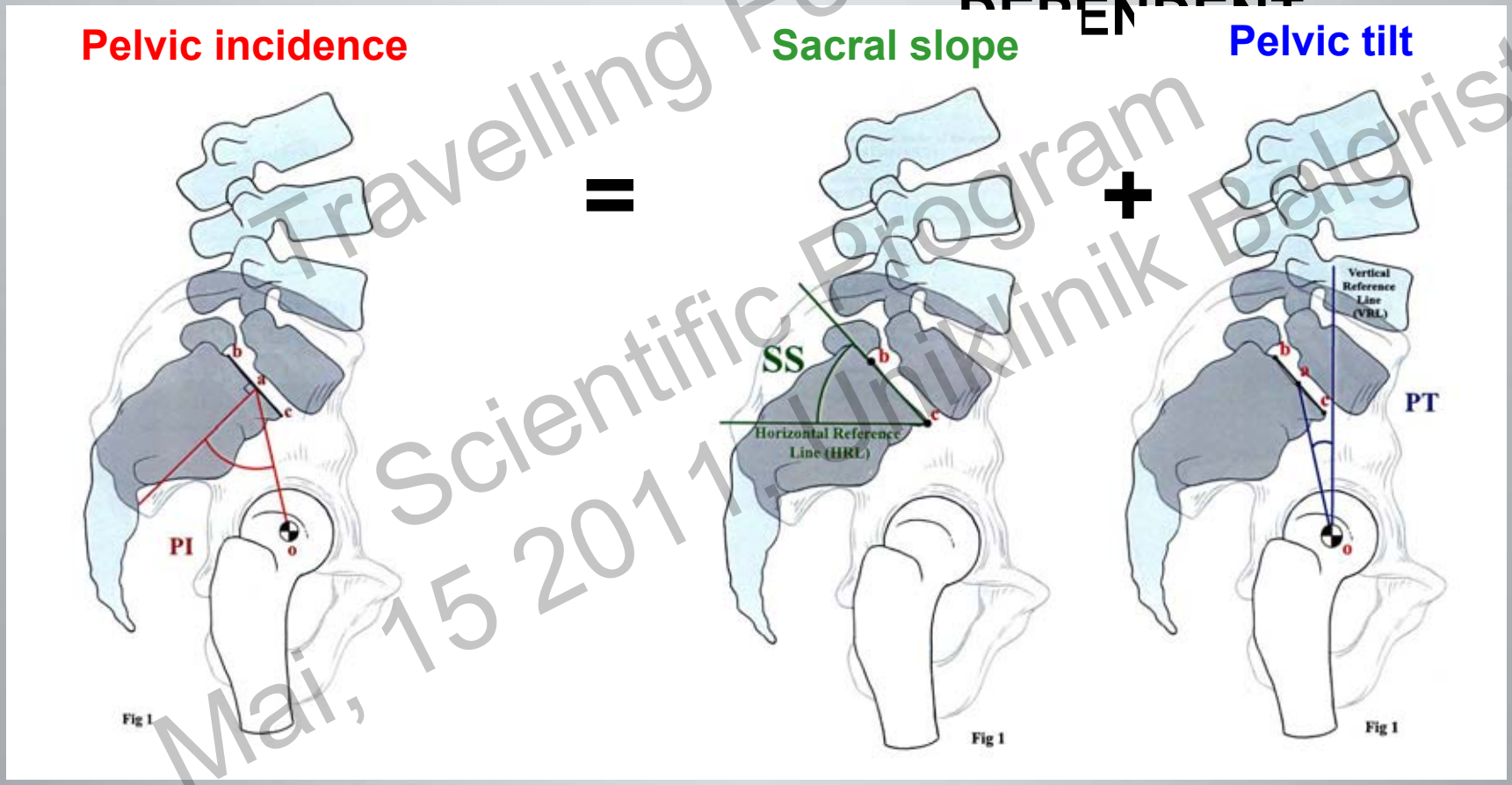
Rationale of the classification

- Sagittal spino-pelvic alignment
  - Sacral and pelvic morphology abnormal in spondylolisthesis (Labelle, Spine 2004)
  - Abnormality in sacro-pelvic morphology increasing with severity of spondylolisthesis (Labelle, Spine 2004)
  - **Potential biomechanical influence of pelvis and sagittal alignment**

Sacro-pelvic morphology and balance

Sacro-pelvic morphology
FIXED

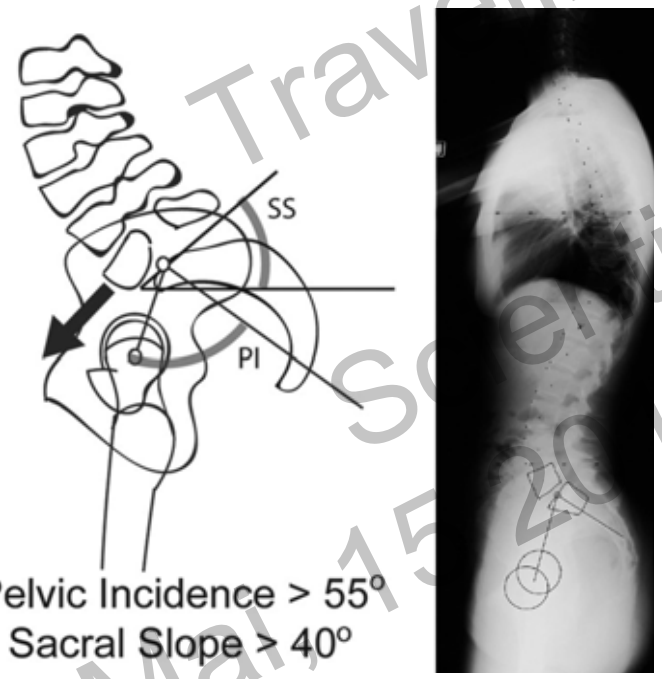
Sacro-pelvic balance
POSITION-DEPENDENT



The influence of sacro-pelvic balance

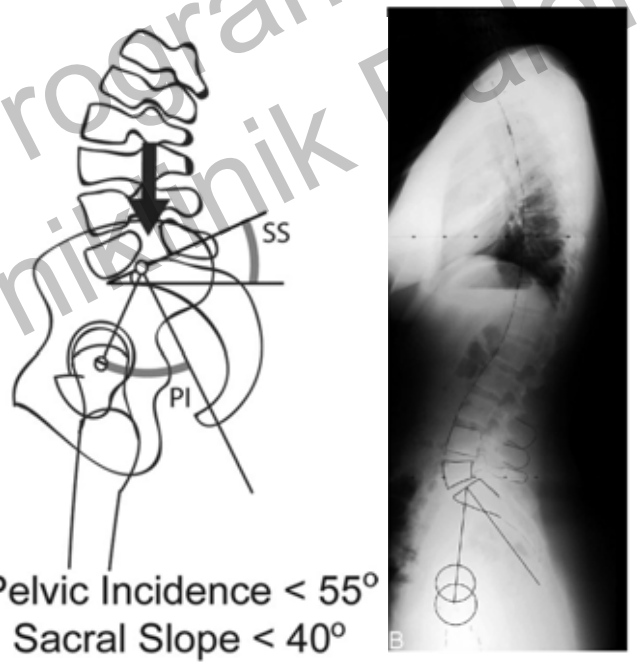
- Low-grade spondylolisthesis (Roussouly, Spine 2006)

Shear type



Pelvic Incidence > 55°
Sacral Slope > 40°

Nutcracker type

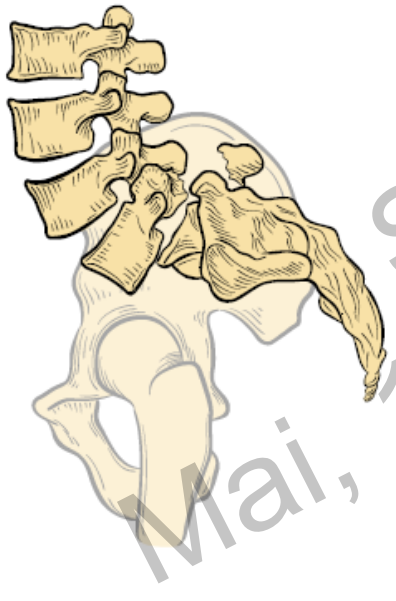


Pelvic Incidence < 55°
Sacral Slope < 40°

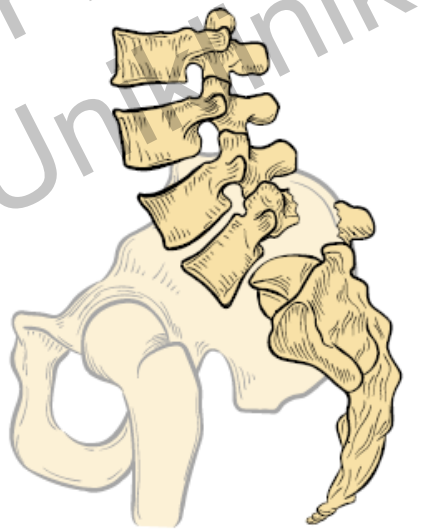
The influence of sacro-pelvic balance

- High-grade spondylolisthesis (Dubousset, Clin Orthop 1997; Hresko, Spine 2007)

Horizontal sacrum (Balanced type)



Vertical sacrum (Unbalanced type)



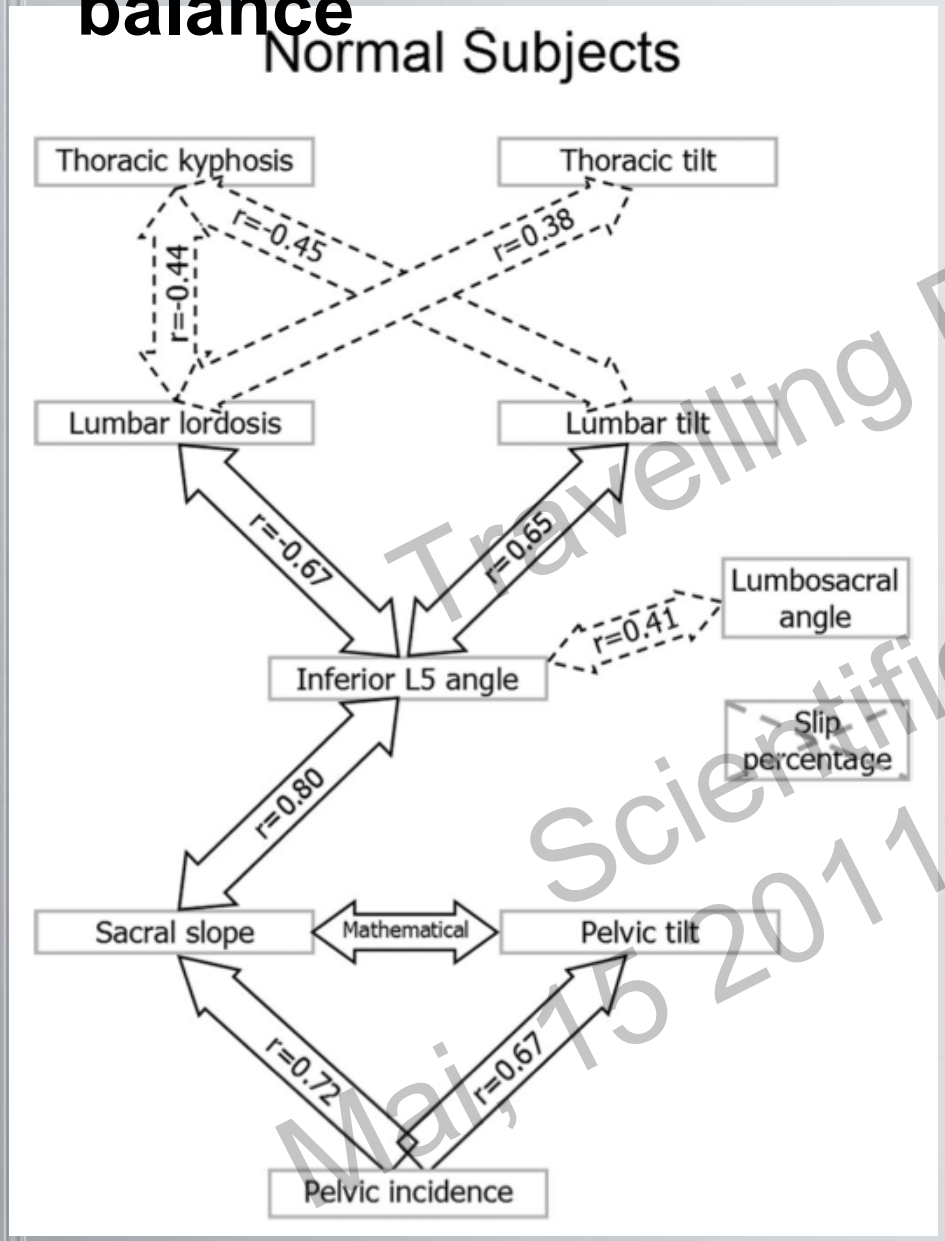
SPINE Volume 33, Number 21, pp 2316–2325

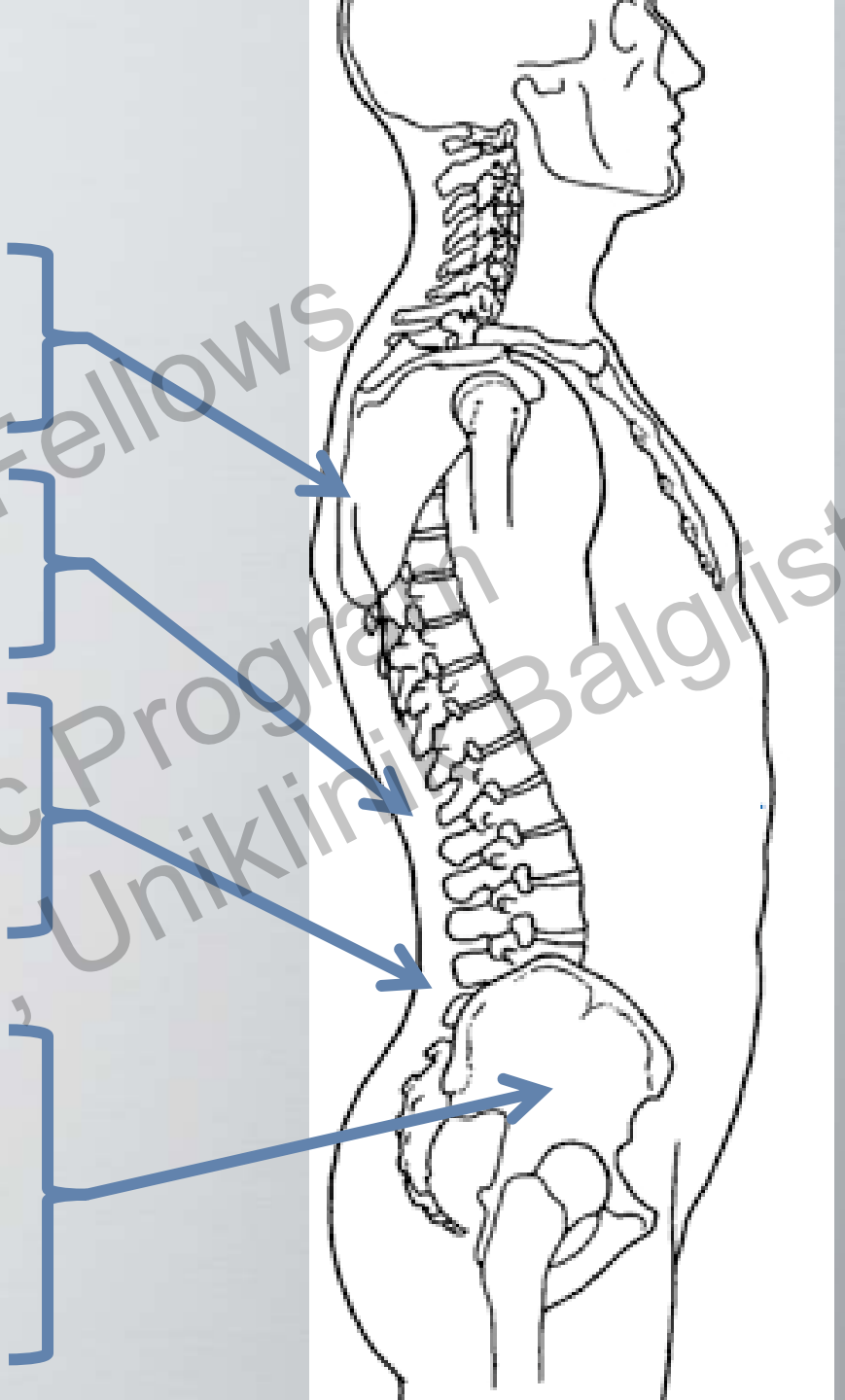
Postural Model of Sagittal Spino-Pelvic Alignment and Its Relevance for Lumbosacral Developmental Spondylolisthesis

Jean-Marc Mac-Thiong, MD,*†‡ Zhi Wang, MD,*†‡ Jacques A. de Guise, PhD,§¶ and Hubert Labelle, MD*†‡

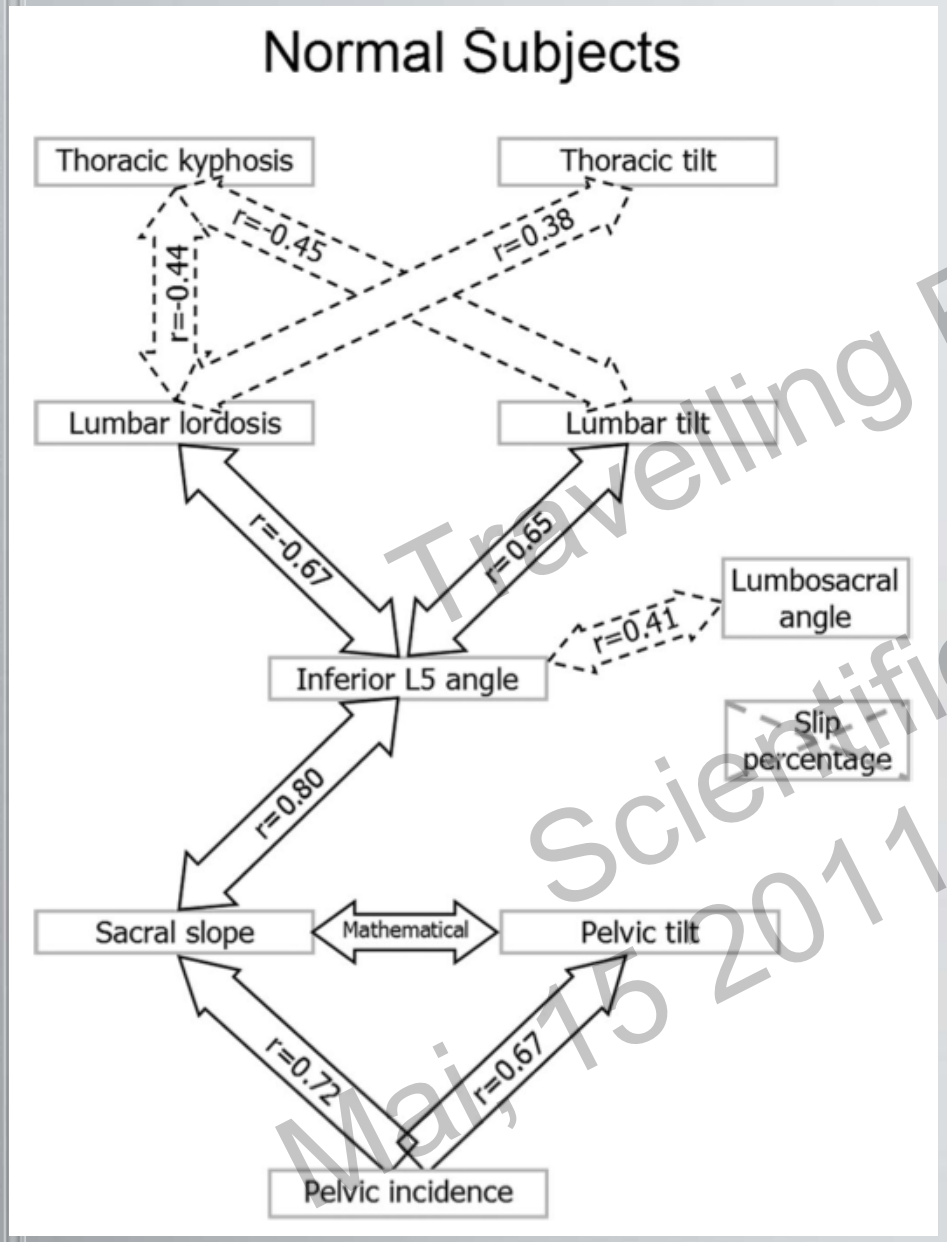
- Premises
  - Normal sagittal balance → relationship between parameters describing adjacent segments of spine-pelvis
  - Abnormal sagittal balance → loss of relationship between parameters describing adjacent segments of spine-pelvis
  - Reduction of spondylolisthesis is necessary for abnormal sagittal balance

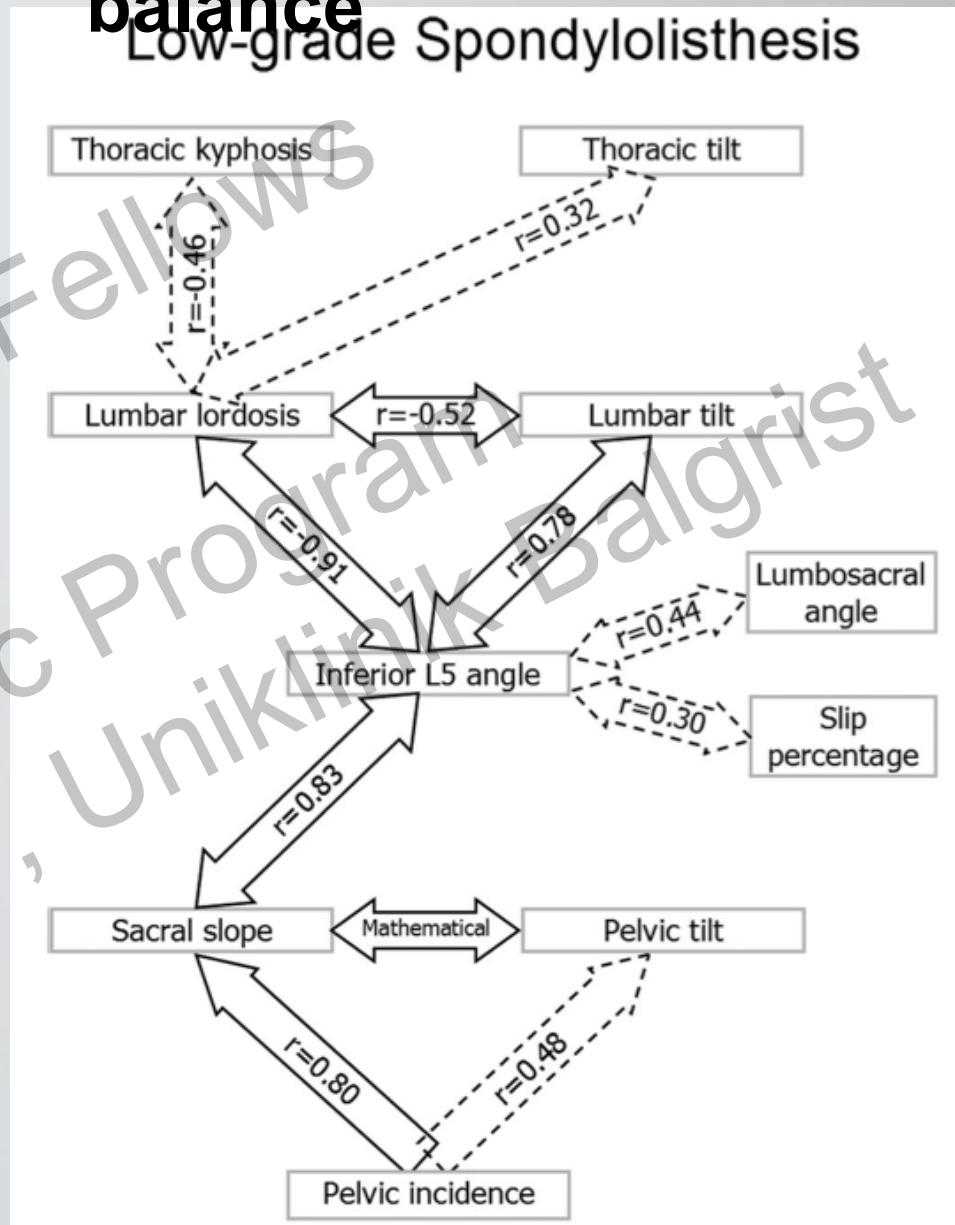
Normal sagittal balance



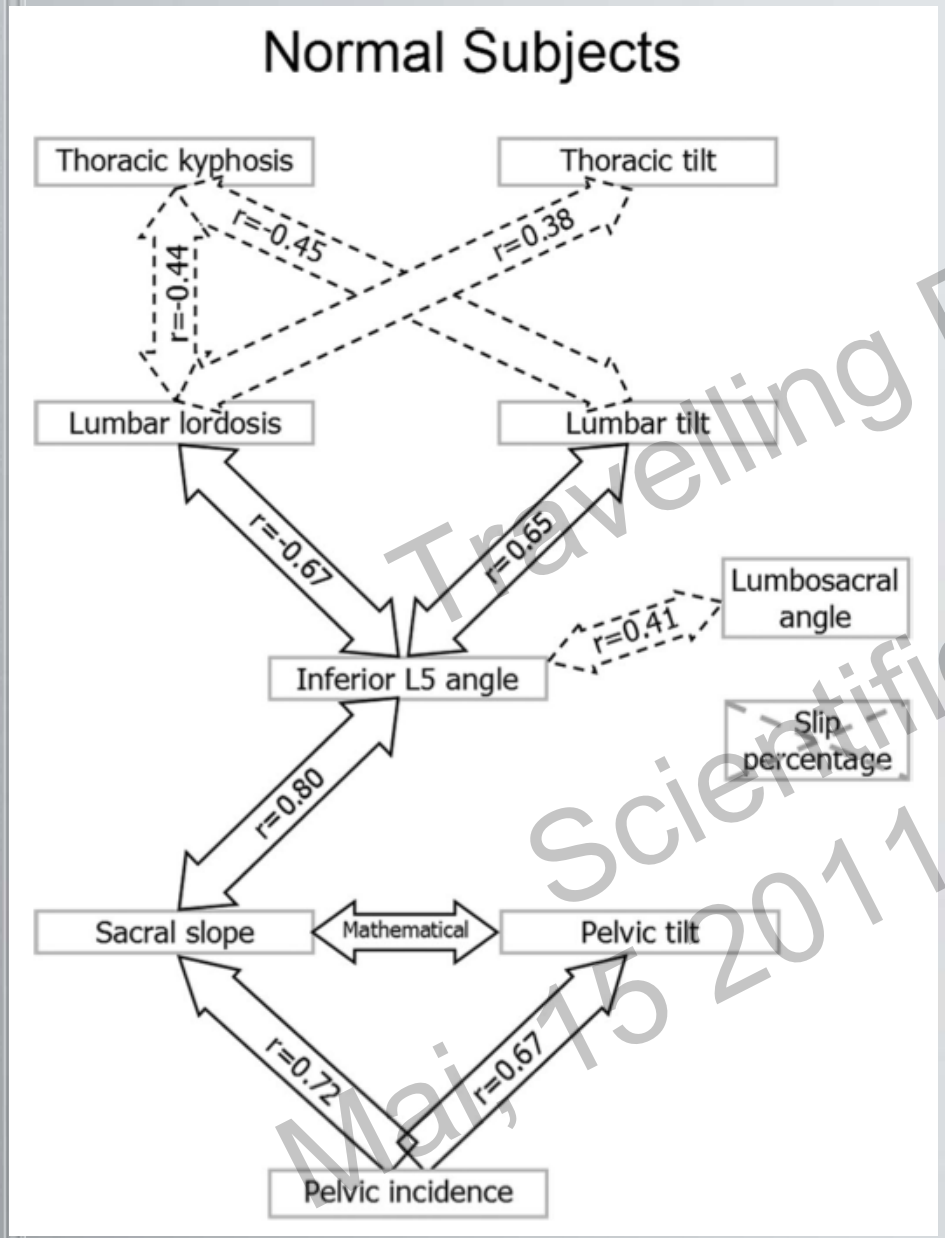


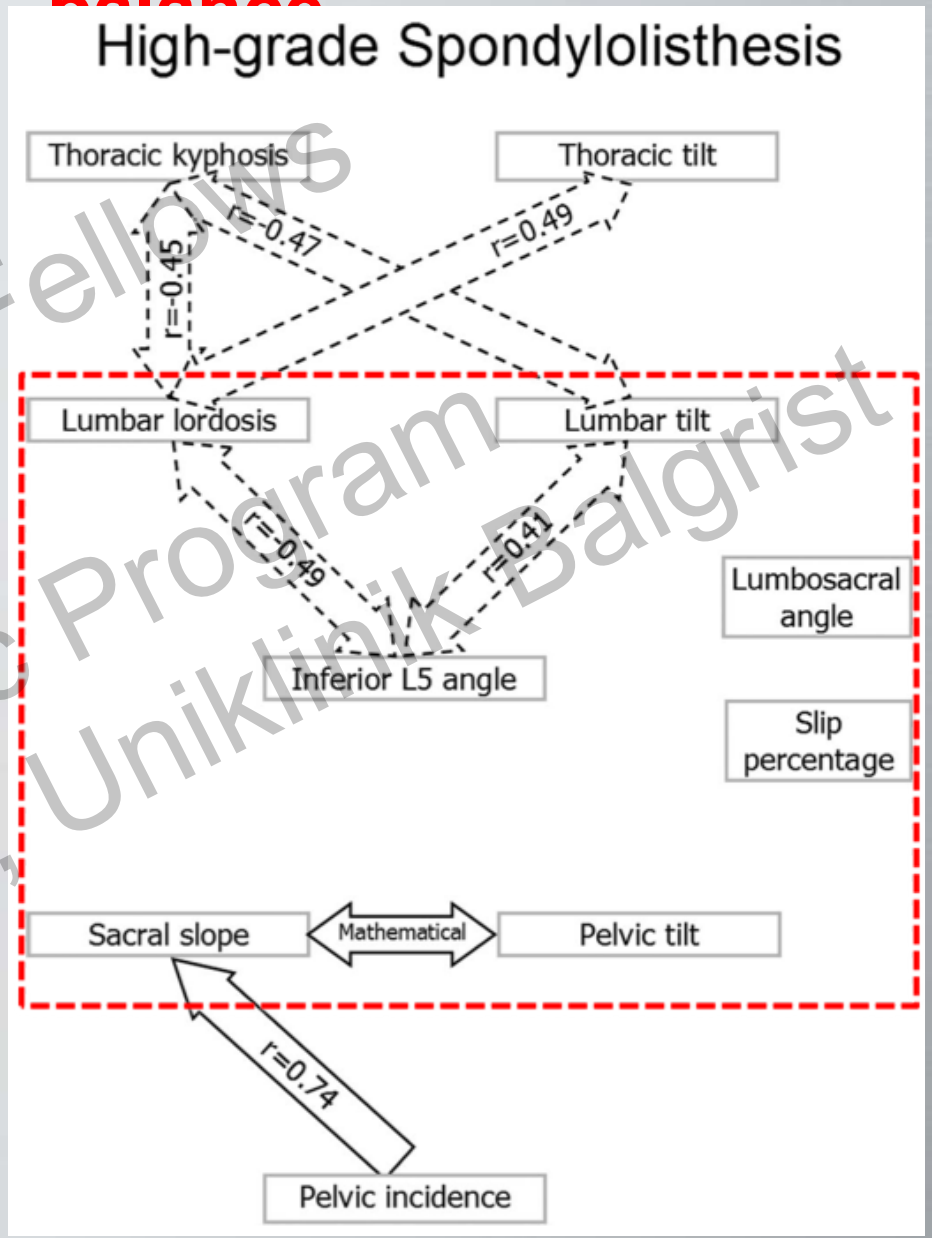
Normal sagittal balance





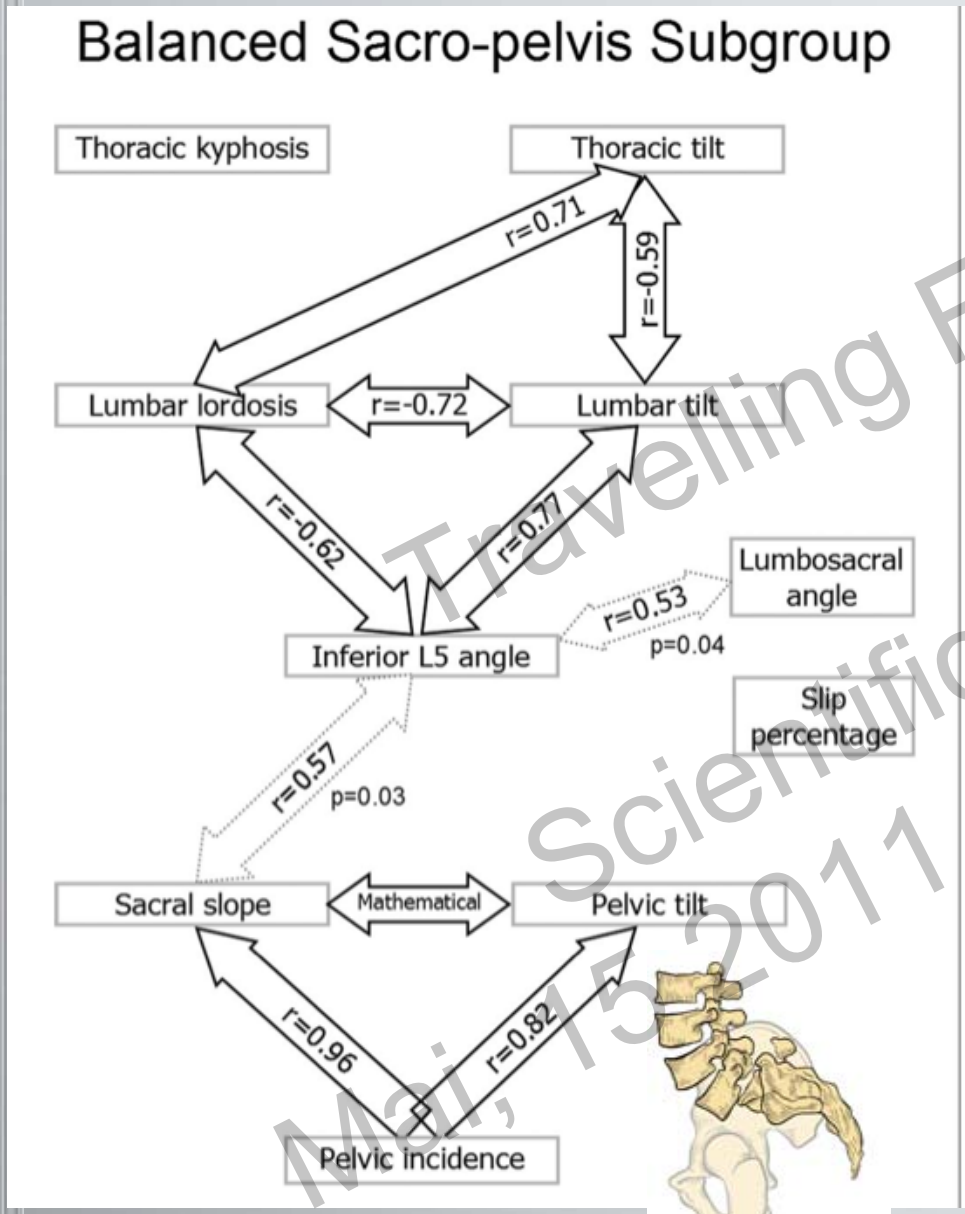
Abnormal sagittal balance

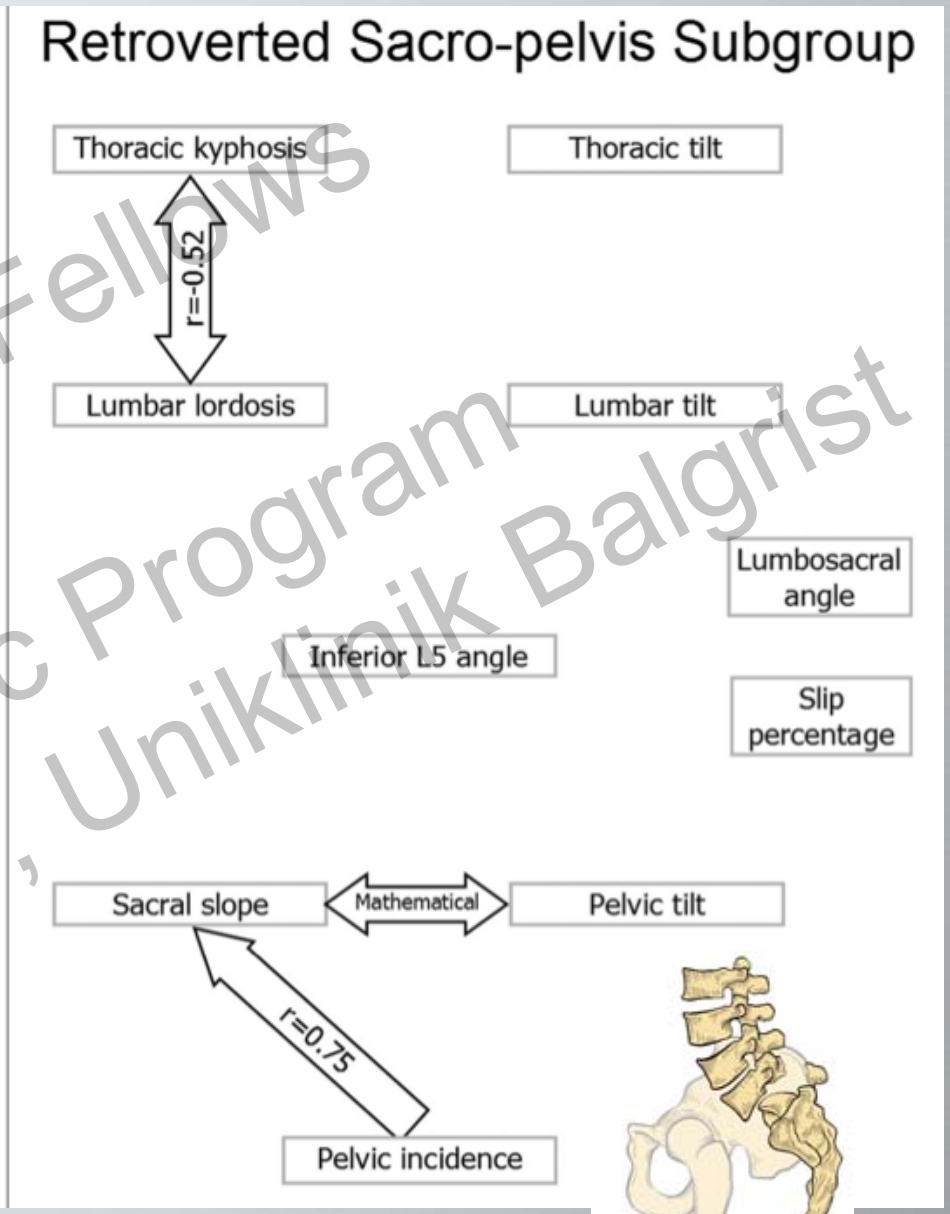




Almost normal balance

Abnormal balance





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Postural Model of Sagittal Spino-Pelvic Alignment and Its Relevance for Lumbosacral Developmental Spondylolisthesis

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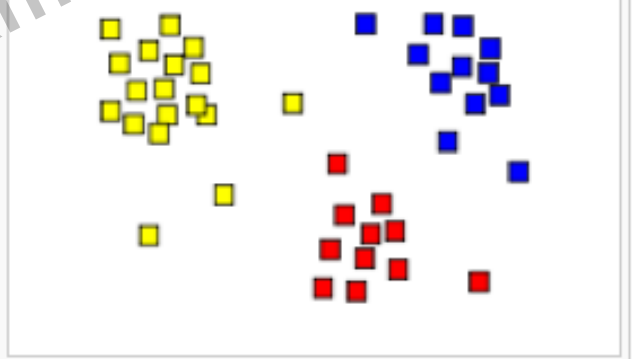
- Surgical reduction of spondylolisthesis to restore normal posture
  - Low grade → **NO**
  - High grade
    - Balanced sacro-pelvis → **NO**
    - Unbalanced sacro-pelvis → **YES ?**

SDSG Classification

- Prospective SDSG database of 816 patients (540 low-grade, 276 high-grade)
- Cluster analysis was used to examine if there were any natural groupings based on parameters of spino-pelvic alignment

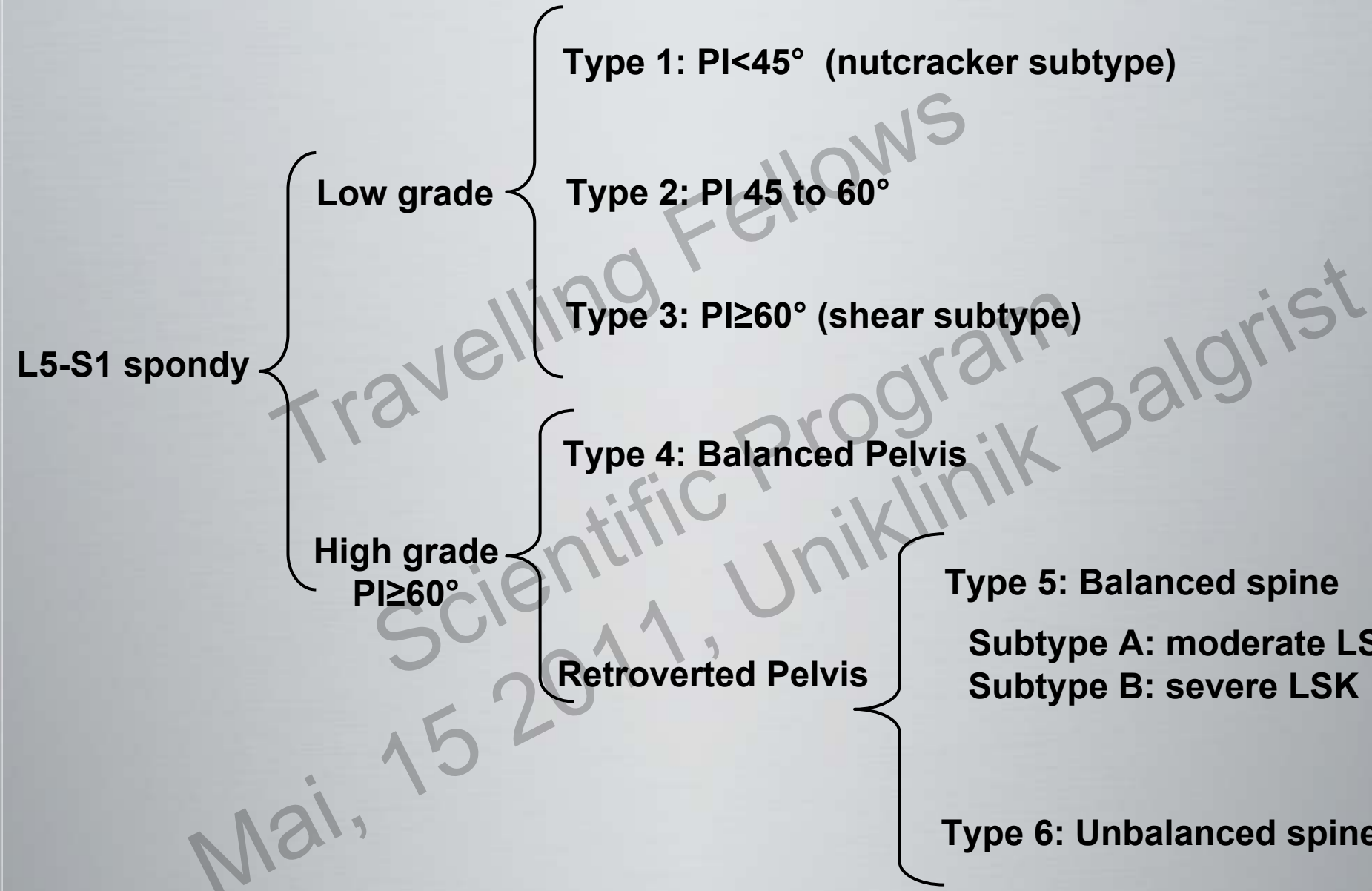
Cluster analysis or **clustering** is the assignment of a set of observations into subsets (called *clusters*) so that observations in the same cluster are similar in some sense. Clustering is a method of unsupervised learning, and a common technique for statistical data analysis used in many fields, including machine learning, data mining, pattern recognition, image analysis, information retrieval, and bioinformatics.



The result of a cluster analysis shown as the coloring of the squares into three clusters.

SDSG Classification

- Prospective SDSG database of 816 patients (540 low-grade, 276 high-grade)
- Cluster analysis was used to examine if there were any natural groupings based on parameters of spino-pelvic alignment
  - Thoracic (thoracic kyphosis, thoracic tilt, number of levels)
  - Lumbar (lumbar lordosis, lumbar tilt, number of levels)
  - Lumbosacral (lumbosacral angle)
  - Sacro-pelvic (pelvic incidence, pelvic tilt, sacral slope)




Type 1
Type 2
Type 3
Type 4
Type 5
Type 6
PI = 32
PS = 24
PT = 8
PI = 55
PS = 43
PT = 12
PI = 95
PS = 74
PT = 21
PI = 86
PS = 63
PT = 23
PI = 62
PS = 27
PT = 35
PI = 82
PS = 37
PT = 45

Reliability

Kappa Statistic	Strength of Agreement
<0.00	Poor
0.00-0.20	Slight
0.21-0.40	Fair
0.41-0.60	Moderate
0.61-0.80	Substantial
0.81-1.00	Almost Perfect

Table 2: The Landis and Koch Kappa benchmark.

	Intra-observer reliability		Inter-observer reliability	
	% agreement	Kappa	% agreement	Kappa
Spondylolisthesis type	79.7%	0.74	71.2%	0.65
Slip grade	92.0%	0.83	88.3%	0.78
Low-grade slips	85.9%	0.76	75.2%	0.63
High-grade slips	87.9%	0.80	83.3%	0.75

Reliability

- Similar to Lenke and King classification for AIS

Study	Classification	Kappa	
		Inter-observer	Intra-observer
Current	**SDSG – 6 types**	**0.65**	**0.74**
Ogon et al. (2002)	Lenke et al. (pre-marked)	0.62	0.73
Richards et al. (2003)	Lenke et al.	0.50	0.60
Richards et al. (2003)	King et al.	0.61	0.80
Cummings et al. (1998)	King et al.	0.44	0.64

Thank you for your attention

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