LEG LENGTH INEQUALITY, SCOLIOSIS, LOW BACK PAIN AND SPONDYLOLYSIS

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The present work aims to analyze the biomechanics of the spine and pelvis and connected pathologies in subjects with leg length inequality (LLI) using diagnostic imaging.

MATERIALS AND METHODS

Over the last 30 years we have examined more than 10,000 young and adult patients.All were submitted to a teleradiographic examination of the spine and pelvis, including the femoral heads, in standing position and in anteroposterior projection. Additionally, where clinically indicated, some patients, above all young adults, were submitted to further in-depth examinations, often including various imaging modalities (CT, MR, etc.).

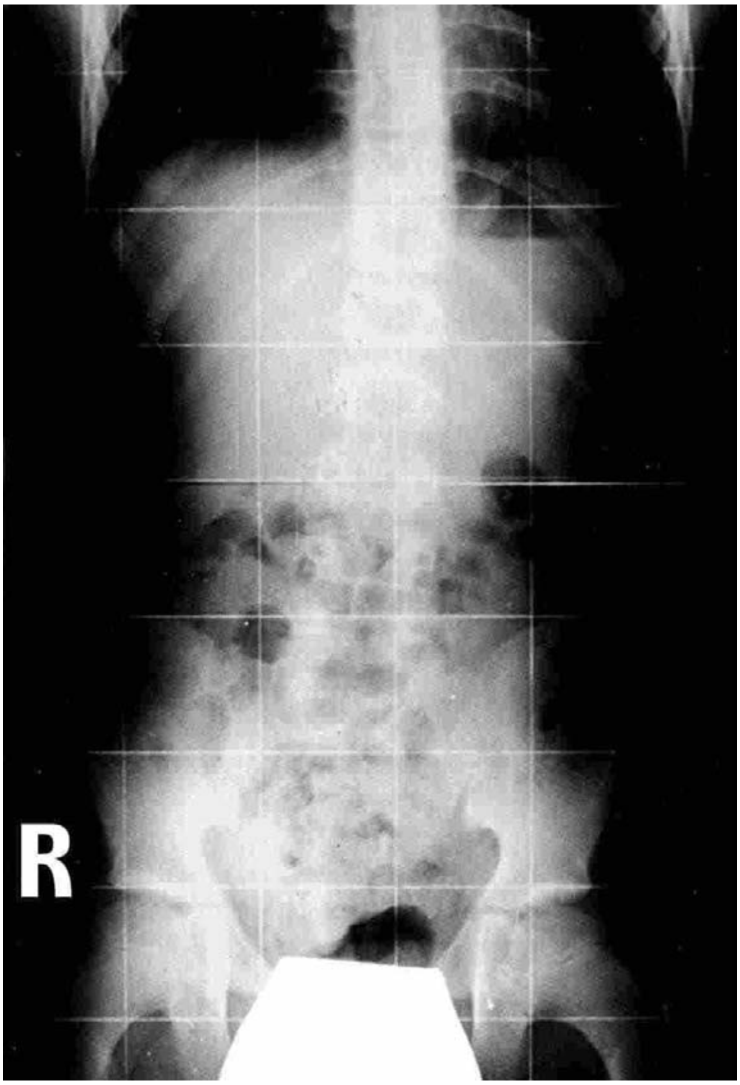


FIGURE 1. ***A 9-year-old child with the left limb a few millimeters shorter and consequent pelvic tilt and left-convex curve***

LEG LENGTH INEQUALITY AND SCOLIOSIS

During growth, LLI, even of the order of just a few mm (Fig.1), can cause a tilt of the pelvis and consequently lateral deviation of the spine and head.The postural response, aimed at re-establishing equilibrium, is a compensatory counterdeviation of the spine.

If the counterdeviation starts at L3 (Fig.2, A) or at a more cranial level, there will be a gradual lumbosacral or thoracolumbosacral curve, convex toward the shorter limb, termed TYPE A;

if the counterdeviation starts at L4 (Fig.2, B1) or L5 (Fig. 2, B2), there will be a brief angular lumbosacral curve, likewise convex to the shorter limb but always followed by a second curve in the opposite direction, termed TYPE **B.**

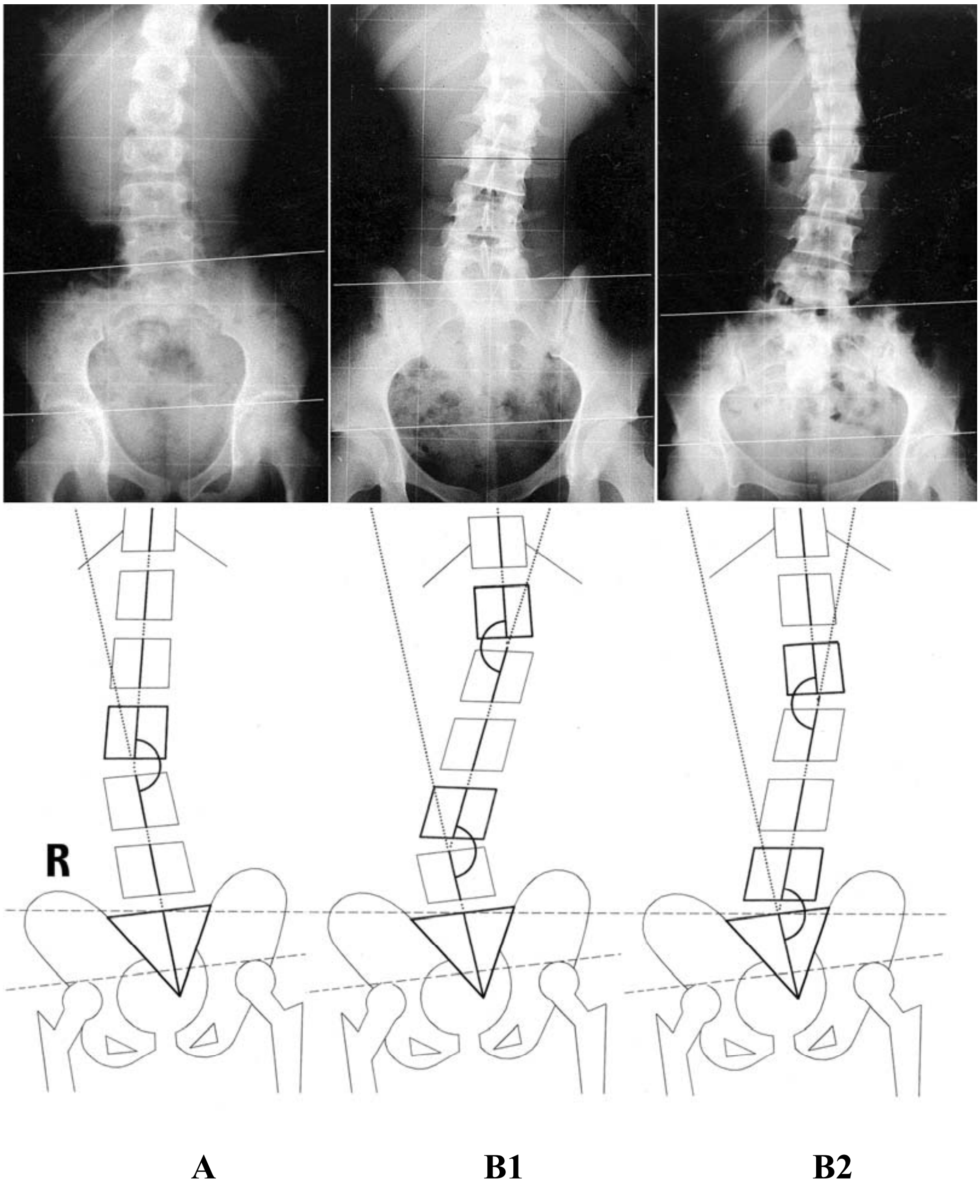


FIGURE 2. ***Type A and type B curves due to shorter right limb (R).***
A), Type A curve with counterdeviation starting at L3.
B1), Type B curve with counterdeviation starting at L4.
B2), Type B curve with counterdeviation starting at L5.

Although the percentage of right and left shorter limbs is virtually the same, type B curves caused by a shorter right limb are far more numerous than those due to a shorter left limb.
During growth, especially in the case of type A curves, additional compensatory curves may appear, which are often more noticeable than the first ones.
Curves that are initially of mild degree, nonstructural and mobile may subsequently diminish, remain stationary or progress and become structural.The course of scoliosis is affected by the load distribution both at the level of the curves because of the greater load along the concave side and, above all, at the lumbosacral level. If it is asymmetric, the overload may produce:

1) WEDGING of the intervertebral disc L4-L5 and/or L5-S1;

2) WEDGING of the vertebral body L4 and/or L5;

3) anterior rotation and TORSION of the ilium with consequent ASYMMETRIC DROP of the SACRAL BASE so that a line passing across the upper border of the sacrum is no longer parallel to the tangential line across the femoral heads, but slopes downward the side of the greater load (Figs. 3 and 4).

FIGURE 3. ***Type B curve due to shorter right limb (R) with counterdeviation starting at L5.***
Anterior rotation and torsion of the left ilium with consequent asymmetric drop of the sacral base.
A line passing across the upper border of the sacrum, compared to the tangential line across the femoral heads, slopes downward the left, the side of the overload.

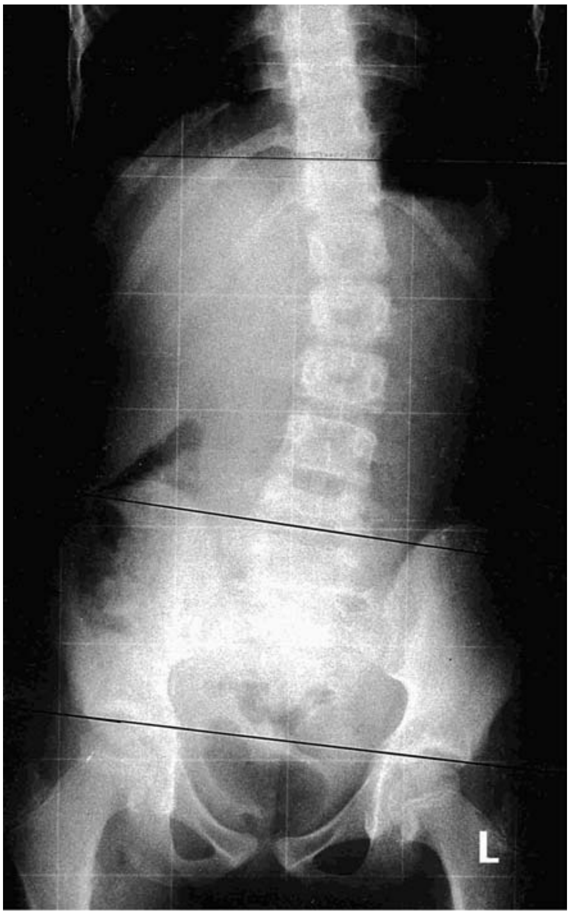
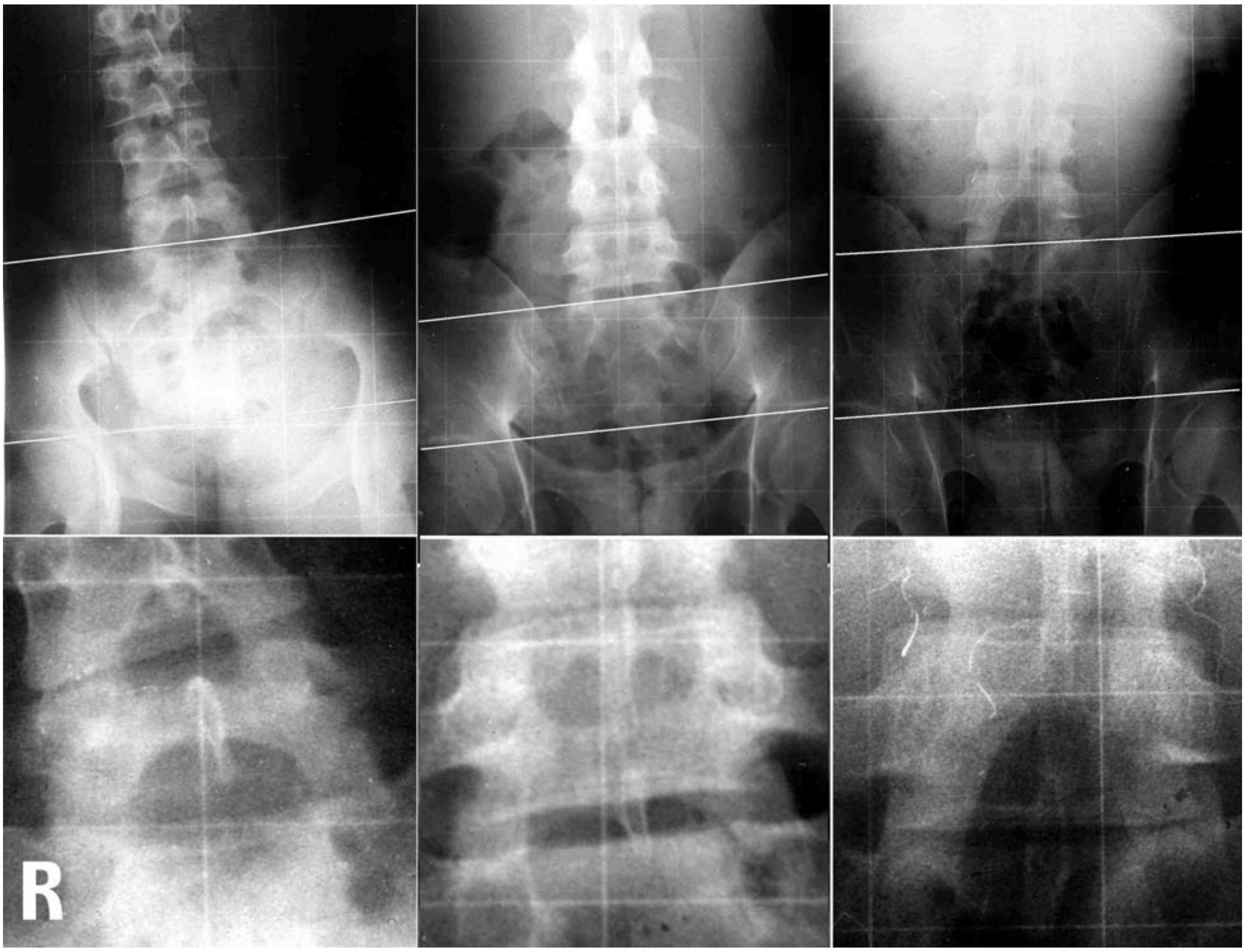


FIGURE 4. ***Type A curve due to shorter left limb (L) with counterdeviation starting at L2 and overload on the side of the shorter limb.***
Anterior rotation and torsion of the left ilium with consequent asymmetric drop of the sacral base.

These changes demonstrate that the load distribution at the lumbosacral level in type A curves may be greater on the side of the shorter limb (Fig. 5, A1), symmetric (Fig. 5, A2), or greater on the side of the longer limb (Fig. 5, A3), whereas in type B curves it is always greater on the side of the longer limb (Fig. 6, B1 and B2).



A1 **A2** **A3**

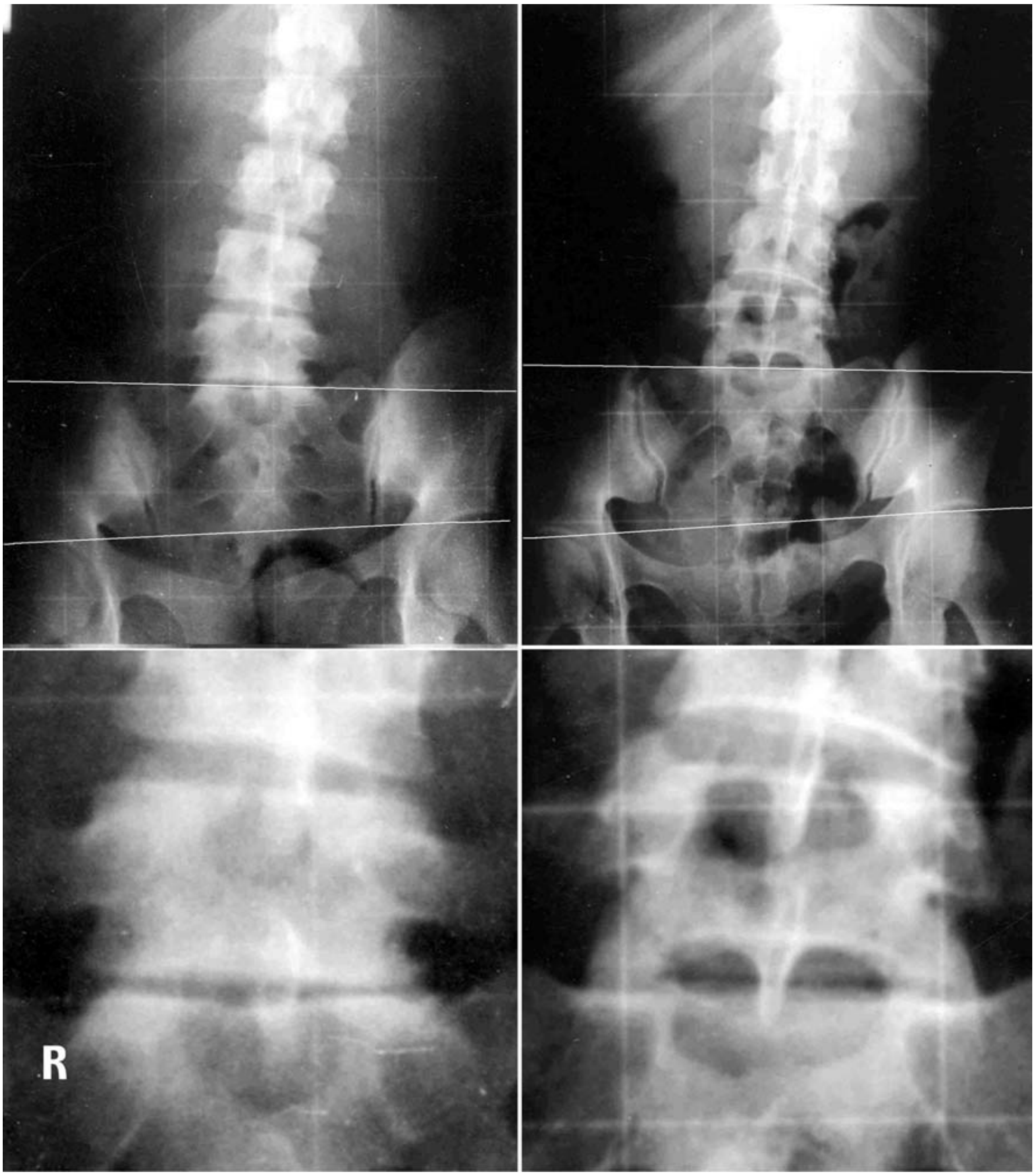
FIGURE 5. ***Type A curves due to shorter right limb (R).***
The radiographic features of the intervertebral spaces L4-L5-S1 and of the basal vertebrae and the orientation of the sacral base compared to the tangential line across the femoral heads show that the load distribution at the lumbosacral level, in type A curves, may be:
A1), greater on the side of the shorter limb (curve subject to progression);
A2), symmetric (curve usually stationary and mild);
A3), greater on the side of the longer limb (curve subject to reduction or disappearance).

By modifying the orientation of the resting surface of the basal vertebrae and the sacrum, the changes mentioned above cause spine deviation in the frontal plane on the side of the greater load. There will be either a progression or a reduction of the curve according to whether the lateral deviation due to asymmetric loading sets up an acting synergism or a compensation. Therefore, in single curve deviations we will have:

- PROGRESSION of the type A curves with overload on the side of the shorter limb, since the lateral deviation due to asymmetric loading is added to the scoliotic deviation due to LLI (Fig. 5, A1);

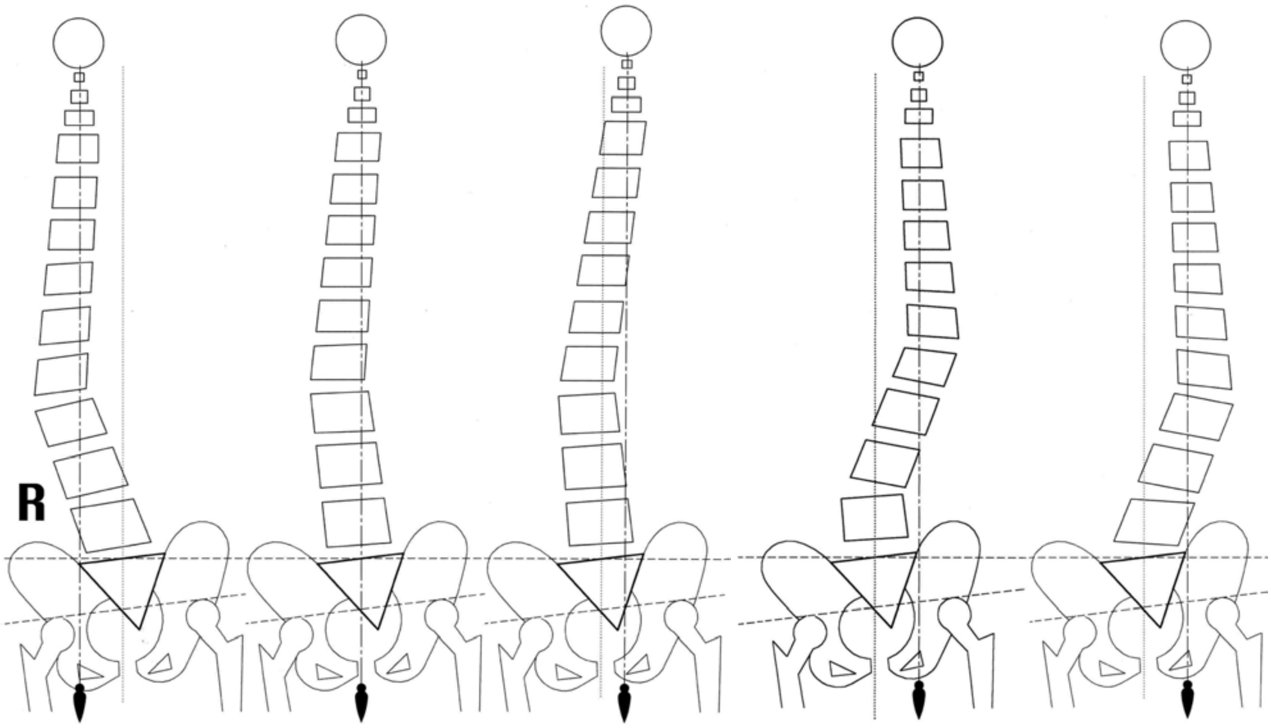
- REDUCTION or DISAPPEARANCE of the type A curves with overload on the side of the longer limb because of the compensation between the two deviations (Fig. 5, A3).

- If, however, the load distribution is symmetric, in the absence of changes at the lumbosacral level, the curve will be STATIONARY (Fig. 5, A2) although there may be slight accentuation in adolescence induced by the wedging of the vertebrae within the scoliotic curve.



B1 **B2**

FIGURE 6. ***Type B curves due to shorter right limb (R) with counterdeviation starting al L4 (B1) and L5 (B2), respectively.***
The wedging of the intervertebral spaces L4-L5-S1, the axial asymmetry of the vertebral body L5 and the asymmetric drop of the sacral base following torsion of the left ilium show that the load distribution at the lumbosacral level, in type B curves, is always greater on the side of the longer limb.



A1 **A2** **A3** **B1** **B2**

FIGURE 7. ***Schematic drawing of the load distributions in type A (A1, A2, A3) and type B (B1, B2) curves due to shorter right limb (R).***

The progression of the scoliosis is greater during adolescence, as this period coincides with the altered axial growth of the vertebrae, both basal and within the curves, which undergo asymmetric loading in accordance with the Hueter-Volkmann principle. Nevertheless, it is not always possible to predict the course of scoliosis because of the shifting of the load due to the appearance of further compensatory curves, as well as posture change if nonstabilized.

In patients with LLI greater than 2 cm, there exist only type A curves. In such cases, since at the lumbosacral level the load is usually greater on the side of the longer limb, the curve is reduced. This means that often the greater the inequality, the lesser the scoliosis and vice versa.

Scoliotic deviations and changes due to asymmetric loads may also be caused by asymmetric transitional vertebrae of the lumbosacral junction. If associated with LLI, the two anomalies may converge in acting synergism or toward a functional compensation.

The fact that anomalous development of limb length occurs in more than one family member would tend to indicate genetic transmission of the condition.

In the treatment of scoliosis, the compensation of LLI using a lift under the heel of the shorter limb is always useful and effective in type A curves with overload on the side of the shorter limb, but may be counterproductive in type B curves or in cases of more curve deviations.

LEG LENGTH INEQUALITY AND LOW BACK PAIN

The overwhelming majority of patients examined for low back pain of uncertain origin had LLI with asymmetric load distribution. Furthermore, the overload at the lumbosacral level may produce:

- MUSCOLAR STRESS;

- PREMATURE DEGENEATIVE DISEASES of the disc-somatic and the interapophyseal joints L4 – L5 and/or L5 - S1;

- DYSFUNCTION (sometimes subluxation) of the sacroiliac joint.

These alterations, involving various structures, might give rise to low back pain. The pain, with or without sciatica, if non caused by herniary pathology, almost always affects the side of the greater load.
The most frequent causes of sciatica are discal herniation and degenerative stenosis of the central canal, of the lateral recess and of the neural foramen.

LEG LENGTH INEQUALITY AND SPONDYLOLYSIS

Similarly, the overwhelming majority of patients with spondylolysis, with or without spondylolisthesis, of L4 and L5 have LLI with asymmetric load distribution at the lumbosacral level. Therefore, since L4 and L5 are affected in over 95% of the total incidence, a correlation between LLI and spondylolysis of the basal vertebrae cannot be excluded.

CONCLUSION

Our findings suggest that LLI is one of the primary cause of scoliosis considered idiopathic, low back pain of mechanical origin and spondylolysis of L4 and L5.

About the subject, Manganiello A. is the author of various papers issued on Italian and International scientific books and journals; he has also taken part, often by request, in following Congresses:

Roma : 1) "XXXIII Congresso Nazionale di Radiologia" - (Presidente) Biagini C – Monduzzi Editore; 1988, pp 923 – 926.

2) "XXVI Congresso Nazionale G. I. S." (Presidente) Logroscino C A; 2003.

Milano: 1) "Second World Week of Professional Updating in Surgery and in Surgical and Oncological Disciplines of the University of Milan" - (eds) Montorsi M and Zennaro F – Monduzzi Editore; 1990, pp 335 – 339.

2) "XXIV Congresso Nazionale G. I. S." (Presidente) Caserta S; 2001.

Montréal : Proceedings of the" International Symposium on 3-D Scoliotic Deformities" - (ed) Dansereau J; 1992, pp 524 – 529.

Lyon : Proceeding of the Congress " European Spinal Deformities Society" - (eds) Kohler R and Picault C. 1992, p 220.

Vienna : 1) Proceedings of the International Symposium on " Advances in Idiopathic Low Back Pain " - (eds) Ernst E, Jayson M I V, Pope M H and Porter R W - Blackwell M Z V; 1993, pp 156 – 160.

2) "Third Interdisciplinary World Congress on Low Back and Pelvic Pain" - Vleeming A, Mooney V, Tilscher H, Dorman T and Snijders C; 1998, pp 418 – 420.

3) Abstracts of the “ 9th World Congress on Pain “ - I A S P Press , Seattle; 1999, p 430.

Poitiers : Proceedings of the “ Second International Symposium on Three-Dimensional Analysis of Human Movement” – (President) Junqua A; 1993, pp 166 – 168.

Noordwijk aan Zee (The Netherlands) : Abstract Book of the “ 6th Annual Meeting ESS European Spine Society” - (President) Postacchini F; 1995, p 109.

Stockholm : First Meeting of the “International Research Society of Spinal Deformities”, 1996 - (eds) Sevastik J A and Diab K M - Research into Spinal Deformities 1, Amsterdam, IOS Press; 1997, pp 111 – 113.

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Barcelona : Book of Abstracts “2 nd Annual Meeting of the Société Internationale De Recherche Et D’etude Sur Le Rachis” - (Presidente) Rigo M - Scoliosis, State of the art; 1996, pp 223 - 224.

Prague : Abstracts of the “ P M R F International Symposium on Clinical Approaches to Spinal Disorders” - (President) Janda V; 1997, p 42.

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Berlin : “First Interdisciplinary World Congress on Spinal Surgery and Related Disciplines” - (eds) Brock M, Schwarz W and Wille C – Monduzzi Editore; 2000, pp 493 – 497.

Paris : “ GIEDA Inter Rachis 15ème Réunion Annuelle” - RACHIS , Vol 14, N° 6 - Dec. 2002, pp 368 – 371.