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ORIGINAL CONTRIBUTION

Prevalence of Frontal Plane Pelvic Postural Asymmetry—Part 1

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Despite 80 years of study, questions of how leg length difference relates to recurrent pain and somatic dysfunction remain controversial. The authors hypothesize that a correlation exists between leg length inequality and back pain. They further hypothesize that if common compensatory patterns described in classic osteopathic medical literature exist, these patterns should interact with the pelvic postural asymmetry patterns of Lloyd and Eimerbrink in a predictable, most probable, and congruent fashion. This article reviews the osteopathic medical, as well as the allopathic medical and chiropractic literature for studies that meet criteria for evidence-based comparison.

Using lumbar radiographic studies produced with subjects standing, the authors examined the prevalence of six types of pelvic postural asymmetry in a consecutive case series of 421 patients with low back pain. Establishing the frequency of pelvic postural asymmetry patterns is a necessary first step in creating an evidence-based foundation to further clarify postural compensatory patterns. Various correlations between and within these patterns are identified.

Asymmetry within the pelvic structure can lead to a cascade of postural compensations throughout the axial spine, predisposing persons to recurrent somatic dysfunction and decreased functionality. Numerous authors have found a correlation between leg length inequality and low back pain (LBP), [1-24] but the question of such a correlation remains a contentious issue.[25-28]

Recently, researchers have argued that LBP in workers has less to do with physical factors and more to do with job dissatisfaction or psychologic predisposition.[29,30] A succession of osteopathic medical researchers have attempted to incorporate aspects of pelvic postural asymmetry into a coherent theoretic framework,[2,5,7-9,18,24,31,32] but few have supported their clinical conclusions with evidence-based data.[1,3,4,5,13,21-23,33] Lloyd and Eimerbrink are credited with developing the most coherent classification system for the evaluation of frontal plane pelvic postural asymmetry,[15] but, to our knowledge, no study of the prevalence of these configurations has been published.

A tacit awareness of leg length asymmetry has undoubtedly existed for millennia. By the late 1800s, a number of published studies reported on the prevalence of leg length inequality, the investigators having used physical measurements on persons and skeletons.[34-36]

The modern era of postural analysis began with the theoretic writings of Lovett[37] and Fryette,[38] and blossomed with the development of radiographs produced with the subject standing for postural studies by Schwab and Hoskins during the period between 1921 and 1934.[39] The literature on short-leg syndrome was reviewed by Beilke in 1936[40] and by Beal in 1950,[7] 1977,[8] and 1988.[9]

In 1937, Bailey and Beckwith[2] published data on the frequency of sacral tilt and correlated this data with contralateral or ipsilateral short-leg measurements. The authors may have been the first to extend a line along the sacral base to intersect perpendicular lines drawn up from the femoral heads, allowing meaningful comparison of the sacral base inclination and inclination of the femoral head unleveling in the frontal plane.

Numerous leg length and postural studies that evaluated children,[35, 43] asymptomatic adults,[6,10,41] soldiers,[6,11] and people with back pain[5,6,10,17,19] were published throughout the 1940s, 1950s, and 1960s in osteopathic medical journals, as well as in allopathic medical and chiropractic publications. During this period, understanding the compensatory mechanisms involved in postural adaptation to short-leg or sacral-base unleveling evolved through the work of Denslow[42] and included discussion of pelvic rotation in the horizontal and sagittal planes.

Lloyd and Eimerbrink, whose classification of pelvic asymmetry will be used in this article, apparently did not publish their results. Their system was presented as part of teaching materials at the Philadelphia College of Osteopathic Medicine, Pennsylvania, during the early 1950s.[15] Although heel lifts have been used for more than 100 years, a definitive correlation of Lloyd and Eimerbrink's classification of pelvic frontal plane asymmetry with a practical system for heel lift intervention did not occur, however, until the publication of an article by Heilig in 1978.[15]

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Questions of how leg length inequality and pelvic postural asymmetry relate to recurrent pain and somatic dysfunction and whether heel lift therapy improves function in the short or long term, remain contentious. The variety and complexity of postural compensatory mechanisms requires a simple, reproducible system for evaluation of pelvic postural asymmetry. Establishing the frequencies with which these patterns occur is a necessary first step in creating an evidence-based foundation of research. This foundation will provide clarification of postural compensatory patterns that will enable physicians to better tailor individual treatment plans and improve treatment efficacy.

Our study examines the prevalence of the six types of pelvic postural asymmetry identified by Lloyd and Eimerbrink. Various correlations between and within these patterns are identified. A similar system should be used to guide heel lift therapy and orthotics construction. Further possibilities for clinical inquiry are also identified.

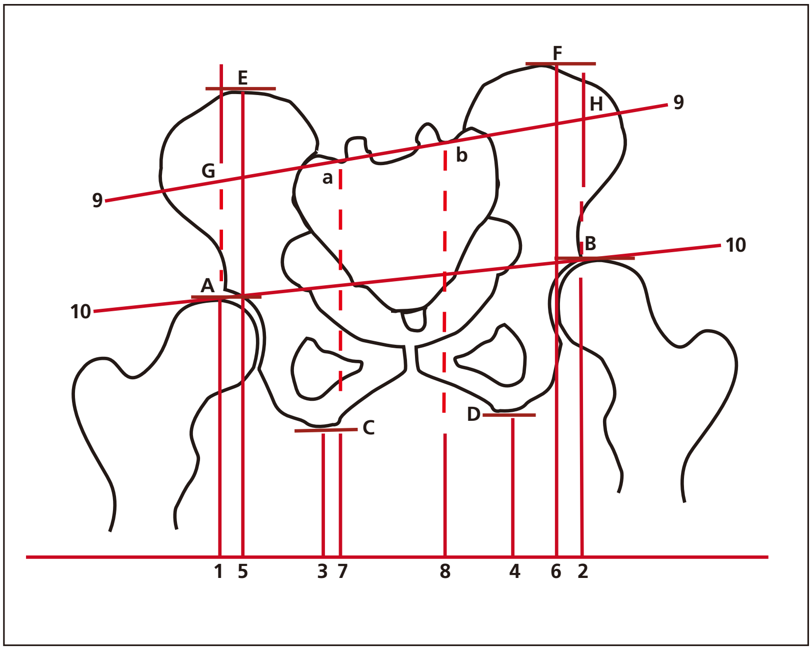

Figure 1. *Measurements for postural x-ray film.*

Step 1. *Erect lines 1 and 2 perpendicular to the base through the highest point of each femoral head. (The base is technically the bottom edge of the film, mounted in a perfectly square light box. The film was shot perpendicular to the x-ray source and parallel and perpendicular to the floor, with patient placement as described in the "Methods" section. As the film is mounted perpendicular to the viewing light box and the measurements are relative, the bottom of the light box is typically used as the reference base. With practice and a transparent T-square, all measurements and calculations can comfortably be done in 3 minutes.);*

Step 2. *Measure the relative heights of points* A, B, C, D, E *and* F *from the base.*

Step 3. *Draw line 9 parallel to the sacral base through the two points labeled* "a" *and* "b," *which represent the convergence of the sacral ala and the articular pillars, as described in the "Methods" section. Measure the relative heights of points* G *and* H *from the base. Line 9 represents the sacral base unleveling (SBU). Line 10 represents the femoral head unleveling (FHU), and may or may not be drawn for clarity. Points* C *and* D *represent the relative heights of the ischial tuberosities (IC), while points* E *and* F *represent the relative heights of the iliac crests (IC).*

Step 4. *FHU* = B–A*; SBU* = H–G*; IC* = F–E*; STHp* = (a–A)–(b–B)*; and SEHp* = (a–C)–(b–D).

Methods

Subjects

Clinicians evaluated 421 consecutive lumbrosacral, anteroposterior (AP) x-ray films deemed clinically appropriate taken between 1994 and 1996 for persons seen at an osteopathic manipulative practice with symptoms related to the low back. Of 421 patients, 240 (57%) were female and 181 (43%) were male. Patients' ages ranged between 13 and 93 years, with a mean age of 47 years.

The osteopathic manipulative practice of this study is located in a major metropolitan area and operates on a fee-for-service format. Although the patient base does not reflect the incidence or prevalence of pelvic postural asymmetry patterns in the general population, the base does represent the prevalence of these patterns in a population that is more clinically useful to the practicing primary care physician.

Equipment

Patients were asked to stand in stocking feet with their feet 6 to 8 inches apart and with knees and hips straight. The technician confirmed that patients' feet were a femoral head–width apart, perpendicular and equidistant to the bucky frame, and that buttocks were lightly touching, but not supported by, the bucky frame, as per Denslow.[42]

All x-ray films were shot with a tube-to-film distance of 40 inches, and the central ray focused at the level of the sacral base. Magnification of the femoral heads was found to vary between 12% and 20%, depending on patients' pelvic AP diameter in conformity with the findings of Denslow.[42] Larger relative distortion occurred in the measurements of iliac crest height.

Procedures

The system used for measuring pelvic asymmetry is essentially that presented in *Foundations for Osteopathic Medicine*,[43] with some modifications (*Figure 1*). The relative heights of the femoral heads, iliac crests, ischial tuberosity, and the convergence of the sacral ala with the articular pillars (points "a" and "b") were measured in millimeters.

Table 1
Historic Measurement Error and Significant Leg Length Inequality

Author	Measurement Error, mm	Amount Considered Significant: Δ Femoral Head Unleveling, mm*	Amount Considered Significant: Δ Sacral Base Unleveling, mm*	Comment
Rush, 1946[6]	1.6	5.0	...	Low back pain
Beal, 1950[7]	1.0–3.0	3.0	...	Low back pain
Denslow, 1962[12]	...	5.0	...	Low back pain
Grofton, 1971[14]	2.5	12.3	...	Hip osteoarthritis
Greenman, 1979[16]	1.5	...	4.0	Low back pain
Giles et al, 1981[17]	1.1	10.0	...	Low back pain
Friberg, 1983[19]	0.6–2.0	5.0	...	Low back pain
Travell, 1983[20]	2.0–5.0	5.0	...	Low back pain

* Delta (Δ) used as prefix to indicate the relative quantitative difference on the low or short side.

Where sacralization of the fifth lumbar vertebrae or technical problems with the x-ray film made evaluation of points "a" and "b" difficult, the white line of eburnation of the sacral base was used to approximate the best line of fit for the weight-bearing plane of the sacral base. This line was extended bilaterally until it intersected perpendicular lines drawn up from the high point of each femoral head, as per Irvin.[21] The femoral head unleveling (FHU) and the sacral base unleveling (SBU) were then calculated.

Visual assessment was made as to whether lumbar scoliosis was present and its degree ("very mild," "mild," "moderate," "severe"), whether the scoliosis was convex to the right or left, and whether the scoliosis appeared to be "C-" or "S-shaped" within the frame of the film. The relative position of the pubic symphysis, with regard to the midheel line, was not recorded, nor was the presence of asymmetric pedal pronation or pes planus.

For purposes of clarity, leg length inequality (LLI) will be used to refer to FHU or SBU or both FHU and SBU collectively. This designation will allow extraction of the group with equal leg lengths (equal group) for separate analysis. For this consecutive case series study, "Equal" is defined as both FHU and SBU less than *X* (where *X* is 4 mm, 10 mm, or 15 mm, as measured on the AP lumbosacral radiograph), according to Denslow.[42] Delta (Δ) will be used as a prefix to indicate the relative quantitative difference on the short or low side. Thus, Δ FHU right indicates a significantly short right leg, and Δ SBU left indicates that the sacral base is significantly low on the patient's left side.

After reviewing historic references (included in *Table 1*), the authors chose a cutoff of 4 mm for significant difference. This cutoff is slightly more than measurement errors reported by most authors and slightly less than what most authors found to represent a clinically significant LLI.

Using Excel language, researchers entered a series of formulas into a Microsoft Excel program (version 7.0) that sorted cases into appropriate categories using cutoffs of 4 mm, 10 mm, and 15 mm for FHU and SBU (*Figure 2*). All other comparisons used 4 mm as a cutoff for significant difference.

All cases were sorted correctly with the following exceptions: Three cases in the 10 mm group were hand sorted into the type IV group (contralateral tilt and unleveling of opposite sides), though neither the Δ FHU nor the Δ SBU was greater than 10 mm, the Δ FHU and Δ SBU were on opposite sides, and the absolute value of their difference was greater than 10 mm. One of these survived into the 15-mm, type IV group. The rationale for this exception is that the type IV pattern is the rarest and often the most difficult to treat clinically. Expansion of this category was deemed desirable in terms of capturing more cases with this type for analysis.

In the 4 mm analysis, 13 cases were correctly classified as type I group (femoral head and sacral base unleveling parallel) by the computer algorithm. All 13 cases had Δ FHU less than 4 mm, and Δ SBU greater than 4 mm to the same side, with the absolute value of the difference between the two less than 4 mm. This barely significant subgroup was deemed more suitable to a type I than a type III (primary sacral tilt, sacral base unleveling only) classification, and the computer algorithm

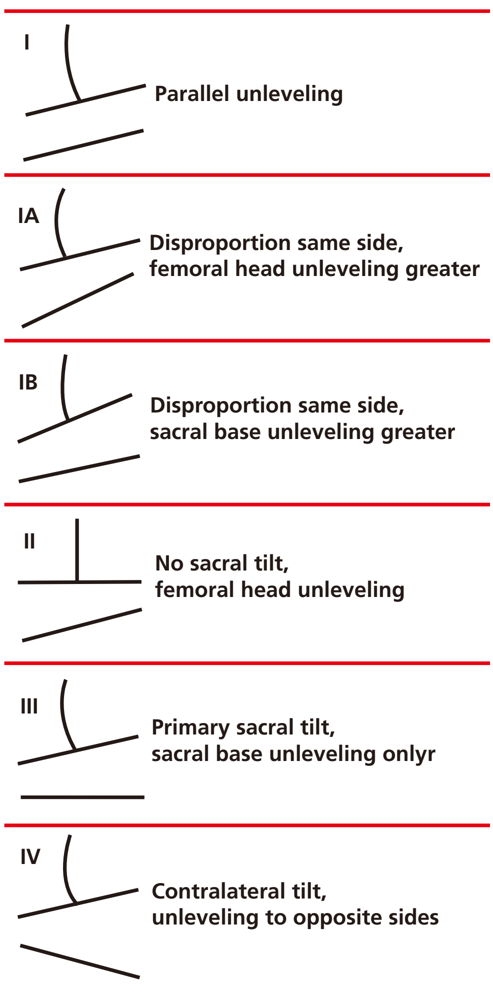

Figure 2. *Types of unleveling, based on the classification of Lloyd and Eimerbrink. (Reprinted from Heilig D. Principles of lift therapy.* J Am Osteopath Assoc. *1978;77:466-472.*

agreed. Therefore, the 13 cases were included in the analysis of prevalence of types as "type I" but were excluded from the subsequent analysis using the groups with a significant Δ FHU as denominator.

Results

In *Table 2*, the 421 cases are sorted by type. In *Table 3*, the "equal group" is separated out so that the relative frequency of Δ LLI can be more easily compared.

The 4-mm cutoff grouping reflects the frequency of types that are probably clinically significant and greater than measurement error. The most common pattern is type I; the rarest pattern is type IV.

The 10-mm cutoff grouping reflects the frequency of types with LLI that are definitely considered clinically significant by most authors. The most common Δ LLI pattern is type IB (disproportion on the same side and sacral base unleveling greater), suggesting that pelvic postural compensatory mechanisms have difficulty maintaining the type I pattern for a larger leg length difference and that these persons are susceptible to additional secondary sacral unleveling.

In the 15-mm cutoff grouping, 82% of cases are categorized as "Equals," having equal leg lengths, but the most common Δ LLI pattern continues to be type IB, which shows a linear increase across the three cutoff groupings. There are no type II cases (femoral head or unleveling but no sacral tilt) in the 15-mm cutoff group. The linear decline of the type II pattern lends further support to the theory that increasing LLI makes it more difficult for pelvic postural mechanisms to compensate.

For purposes of comparison, the authors reviewed historic studies to ascertain whether they met the following criteria: LLI was quantified, the measurement system was described, and the study included more than 100 patients with radiologic confirmation.

Table 4 presents studies that met these criteria and whose data could be compared. Four of the studies[6,10,17,19] include data for cases with and without LBP. The combined frequency of Δ FHU for cases with LBP is higher than that of control subjects for 4-mm, 10-mm, and 15-mm significance levels. Data for Δ SBU and Δ LLI are not available for comparison with data for control subjects but would undoubtedly strengthen the association between LLI and LBP. Given the large number of studies done during such an extended time, a great deal of variability exists in the results. Schwab's finding in 1932 that 64% of 540 cases had ≥ 10 mm Δ FHU may reflect a higher prevalence of polio in the population at the time.[1] Friberg's study from 1983 is the most comparable: 53% with short right leg refers to the combined group of cases and control subjects (1010).[19] This percentage undoubtedly dilutes the percentage of cases with LBP and short right leg. For the current 421 consecutive-case study, 276 (66%) cases had a Δ FHU of ≥ 4 mm, and 189 of them had a short right leg. These results are within the range of comparable historic studies.

A separate analysis compared the frequencies of the seven pelvic patterns in 421 consecutive lumbrosacral radiographs taken between 1994 and 1996 with 400 radiographs taken between 1998 and 2000. The frequency of patterns was essentially unchanged (data not shown). The lack of drift in the data from the two time frames strengthens the hypothesis that pelvic pattern frequencies represent the actual prevalence in a broader population of cases with LBP.

Equal Group

Using the ≥ 4-mm cutoff, 79 (18.8%) of the cases' pelvic patterns represented in the 421 radiographs were classified as "equal" (*Table 3*). This is near the frequency one would expect if the distribution were equal across all seven possible pelvic

Table 2
Consecutive Lumbosacral Radiographs (n=421) Sorted by Type Using Three Cutoffs for Significance: Greater Than or Equal to 4, 10, and 15 Millimeters

Type of Unleveling	Δ4 mm* No.	Δ4 mm* Percent of Total	Δ10 mm* No.	Δ10 mm* Percent of Total	Δ15 mm* No.	Δ15 mm* Percent of Total
■ Equal Leg Lengths	79	18.8%	238	56.5%	346	82.2%
■ I (Femoral head and sacral base unleveling parallel)	117	27.8%	49	11.6%	14	3.3%
■ IA (Disproportion same side, femoral head leveling greater)	22	5.2%	18	4.3%	7	1.7%
■ IB (Disproportion same side, sacral base unleveling greater)	76	18.1%	72	17.1%	44	10.4%
■ II (No sacral tilt, femoral head unleveling)	43	10.2%	7	1.7%	0	0
■ III (Primary sacral tilt, sacral base unleveling only)	66	15.7%	28	6.7%	8	1.9%
■ IV (Contralateral tilt, unleveling of opposite sides)	18	4.3%	9	2.1%	2	0.5%

* Delta (Δ) used as prefix to indicate the relative quantitative difference on the low or short side.

patterns. Further insights into why persons with equal leg length develop LBP will be the focus of part 2 of this article, with discussion of the frequencies of scoliosis and short-seated hemipelvis.

Type I Group

The type I pattern displays the most common compensatory response to a short leg. The Δ SBU remains parallel to the Δ FHU. The relative frequency falls off as the cutoff increases through ≥10 mm to ≥15 mm. The commonest compensatory response to a type I pattern is ipsilateral convex scoliosis. This will be explored in part 2.

Type II Group

The type II pattern displays ideal compensation for a short leg by a leveling of the sacral base. It occurs relatively infrequently and decreases from 13% to 0 as the cutoff for Δ FHU increases.

Type IA Group

The type IA pattern (disproportion same side, femoral head unleveling greater) falls functionally between the type I and type II groups. The sacrum partially compensates for the short leg but not completely, as in the type II pattern. Type IA frequency through the three cutoff groups remains relatively stable, most likely the result of absorption of the faltering type II group that is completely extinguished by the ≥ 15-mm cutoff of ≥ 15 mm. The type 1A pattern is the second rarest pattern in this series of cases of LBP.

Type III Group

The type III pattern (with sacral base unleveling only) represents primary sacral dysfunction. In the absence of any significant short leg, the sacrum appears to have fallen on one side in the AP view. The frequency of the type III pattern is diminished across the three cutoff groupings (*Table 3*). This may reflect the increasing improbability that the pelvis can accommodate such a large sacral unleveling or may reflect the relative shortage of cases with such a large Δ LLI in this database. Between 70% and 75% of cases with the type III pattern have an associated scoliosis (data not shown).

Type IB Group

The type IB pattern is functionally similar to the type III pat-

Table 3
Group With Equal Leg Lengths Separated for Comparison of Relative Frequency of Leg Length Inequality (n=421)

Type of Unleveling	Δ 4 mm* No.	Δ 4 mm* Percent of Total	Δ 10 mm* No.	Δ 10 mm* Percent of Total	Δ 15 mm* No.	Δ 15 mm* Percent of Total
■ Equal Leg Lengths	79	18.8%	238	56.5%	346	82.2%
■ Unequal Leg Lengths	342	81.2%	183	43.5%	75	17.8%
■ II (No sacral tilt, femoral head unleveling)	43	12.6%	7	3.8%	0	0
■ IA (Disproportion same side, femoral head leveling greater)	22	6.4%	18	9.8%	7	9.3%
■ I (Femoral head and sacral base unleveling parallel)	117	34.2%	49	26.8%	14	18.7%
■ IB (Disproportion same side, sacral base unleveling greater)	76	22.2%	72	39.3%	44	58.7%
■ III (Primary sacral tilt, sacral base unleveling only)	66	19.3%	28	15.3%	8	10.7%
■ IV (Contralateral tilt, unleveling of opposite sides)	18	5.3%	9	4.9%	2	2.7%
Total	**342**	**100.0%**	**183**	**100.0%**	**75**	**100.0%**

* Delta (Δ) used as prefix to indicate the relative quantitative difference on the low or short side.

tern. The ipsilateral Δ SBU is larger than the Δ FHU. The relative frequency increases across the three cutoff groupings (*Table 3*), accounting for more than half of the Δ LLI at the ≥15-mm cutoff. This increase suggests that in these cases, sacral unleveling is acquired and secondary to the Δ FHU.

Type IV Group

The type IV pattern displays overcompensation for a short leg by a tilting of the sacral base to the contralateral long leg side. At first viewing, these differences seem to cancel each other out, but, in fact, the patient is left with conflicting messages from the lower extremity and torso proprioceptors. The convexity of lumbar scoliosis tends to follow the sacral base unleveling rather than the Δ FHU (*Table 5*). The type IV pattern is the rarest pattern at the ≥ 4 mm significance level, but unlike the type II pattern, the type IV pattern persists up through the ≥15-mm cutoff.

Age Correlations

Beilke[49] theorized in 1936 that there was a progression from type I to type II to type IV patterns but did not publish any data. In 1943, Kerr[5] presented data for 150 cases but did not find a progression of patterns based on age or duration of symptoms.

In *Table 5*, clinician sorted cases with each of the pelvic types by age using the 10-mm cutoff. As a Bell curve for age distribution was represented in the data, the authors normalized each age group to 100% for more meaningful comparison. The database also does not support the concept of a time-dependent progression from one pelvic pattern to another, even when omitting the underrepresented youngest and oldest decade age groups or combining types with similar functional attributes at either the 4 mm or 10 mm significance level.

To the degree that the combined type IB and type III group represent primary sacral dysfunction, the constancy of their frequency through the age groups is notable.

Table 4
Comparison With Historic References for Relative Quantitative Difference on the Short or Low Side of Leg Length Inequality

Investigator	Subjects Studied (No.)	Δ Femoral Head Unleveling as Percentage of Total* ≥4 mm	≥10 mm	≥15 mm	Short Right Leg
Pearson, 1951[35]	Children aged 5–13 y (736)	81.0%	4.0%	...	44.0%
Pearson, 1949[33]	Children aged 5–13 y (710)	78.0%	2.0%	...	45.0%
Schwab, 1932[1]	Adults (540)	...	64.0%	...	...
Kerr, 1943[5]	Adults with low back pain (150)	62.0%	...	...	54.0%
Rush, 1946[6]	Control subjects (100)	33.0%	4.0%	...	66.0%
	Soldiers with low back pain (1000)	37.5%	15.0%	...	55.0%
Stoddard, 1959[10]	Control subjects (50)	72.0%	8.0%	...	...
	Adults with low back pain(100)	86.0%	17.0%	...	...
Denslow, 1962[12]	Male medical students (361)	48.0%	9.0%	...	66.0%
Giles, 1981[17]	Control subjects (50)	...	8.0%	...	...
	Adults with low back pain (1309)	...	19.0%	...	...
Friberg, 1983[19]	Control subjects (359)	44.0%	15.6%	2.2%	53.0%
	Adults with low back pain (653)	75.0%	18.4%	11.7%	...
Juhl, 2004	Patients with low back pain (421)	66.0%	28.0%	7.1%	68.0%

* Delta (Δ) used as prefix to indicate the relative quantitative difference on the low or short side.

Handedness

Because of the exigencies of clinical life, data on handedness were not collected for all of the cases in the original database. An extended database was used to document 409 cases of handedness, with 365 (89%) of the 409 cases found to be right-handed (*Table 6*). Of 290 right-handed cases with significant LLI, 181 (63%) had a short right leg. Of 203 right-handed patients with scoliosis, 114 (56%) had convexity to the right. If one assumes that functional scoliosis tends to be convex to the ipsilateral short-leg side, then adding back convex left scoliosis cases with a short left leg should result in a higher correlation between LLI and ipsilateral scoliotic convexity. In fact, of the 203 cases of right-handed with LLI and scoliosis, 174 (85%) had scoliosis convex to the side of LLI. The much stronger correlation of scoliotic convexity to Δ SBU than to Δ FHU can be appreciated by looking at the type II group in *Table 6*. Barely 42% of cases with scoliosis were convex to the short-leg side in the absence of SBU, while 85% were in effect convex to the side of SBU for all groups combined, confirming the clinical observations of Greenman.[16]

In the current handed series, 11% of cases were left-handed. This is notably close to the generally accepted frequency of left-handedness in the general population (1 in 10). Of 44 left-handed cases with LBP, 40 had a significant LLI. Of the 40 cases with significant LLI, 21 had a Δ LLI short on the left side, and 18 (45%) had scoliosis convex to the left.

A disproportionately large number of cases in the left-handed group (8/44) [18%] had a type IV pelvic pattern. That the rarest and most difficult to treat pelvic postural pattern had such a high prevalence among left-handed cases may be puzzling, or it may simply be a statistical aberration of a small database.

Table 5
Pelvic Types Organized by Patient's Age: 10-Millimeter Cutoff

Age, y	Group* Equal	I	II	IA	IB	III	IV	Total
■ Raw Data for Pelvic Types Separated by Age (No.)								
□ 13–22	6	0	0	0	1	1	1	9
□ 23–32	36	9	1	4	14	3	0	67
□ 33–42	64	14	2	6	21	8	2	117
□ 43–52	48	8	1	3	9	8	4	81
□ 53–62	35	9	0	2	12	3	1	62
□ 63–72	33	4	2	2	9	3	1	54
□ 73–82	13	4	1	1	4	2	0	25
□ 83–93	3	1	0	0	2	0	0	6
Total	**238**	**49**	**7**	**18**	**72**	**28**	**9**	**421**
■ Raw Data Converted to Percentage								
□ 13–22	66.7	0	0	0	11.1	11.1	11.1	100
□ 23–32	53.7	13.4	1.5	6.0	20.9	4.5	0	100
□ 33–42	54.7	12.0	1.7	5.1	17.9	6.8	1.7	100
□ 43–52	59.3	9.9	1.2	3.7	11.1	9.9	4.9	100
□ 53–62	56.4	14.5	0	3.2	19.4	4.8	1.6	100
□ 63–72	61.1	7.4	3.7	3.7	16.7	5.6	1.9	100
□ 73–82	52.0	16.0	4.0	4.0	16.0	8.0	0	100
□ 83-93	50.0	16.7	0	0	33.3	0	0	100
■ Functionally Similar Groups Combined (%)								
□ 13–22								
□ 23–32		13.4	7.5		25.4			
□ 33–42		12.0	6.7		24.7		1.7	
□ 43–52		9.9	4.9		21.0		4.9	
□ 53–62		14.5	3.2		24.2		1.6	
□ 63–72		7.4	7.4		22.3		1.9	
□ 73–82		16.0	8.0		24.0			
□ 83–93								

* I = Femoral head and sacral base unleveling parallel.
II = No sacral tilt, femoral head unleveling.
IA = Disproportion same side, femoral head leveling greater.
IB = Disproportion same side, sacral base unleveling greater.
III = Primary sacral tilt, sacral base unleveling only
IV = Contralateral tilt, unleveling of opposite sides.

Apart from the obvious conclusion that patients with LBP tend to have a Δ LLI on the side of their dominant hand, the high frequency of type IV pattern among the left-handed is the most clinically significant finding to emerge from these handedness data.

Looking Forward

Establishment of the frequencies of pelvic postural asymmetry patterns is a necessary first step in creating an evidence-based foundation for quantifying postural compensatory patterns, leading to individualized treatment plans and improved treat-

Table 6
Pelvic Types Related to Handedness

Type ⩾4 mm	Right Handed: Total No.	Right Handed: No. (%) With Right Δ LLI*	Right Handed: No. (%) Also Having Scoliosis Convex Right	Left Handed: Total No.	Left Handed: No. (%) With Left Δ LLI	Left Handed: No (%) Also Having Scoliosis Convex Left	Total No. (%) With Scoliosis Convex to Δ LLI
■ Equal Leg Lengths	75		14 R, (17L)	4			
■ I (Femoral head and sacral base unleveling parallel)	86	56/86 (65%)	35/52 (56%)	11	3/11 (27%)	3/8 (37%)	47/63 (75%)
■ IA (Disproportion same side, femoral head leveling greater)	19	16/19 (84%)	10/13 (77%)	2	0	0	13/15 (87%)
■ II (No sacral tilt, femoral head unleveling)	21	14/21 (66%)	6/12 (50%)	4	3/4 (75%)	1/1 (100%)	7/13 (54%)
■ IB (Disproportion same side, sacral base unleveling greater)	75	47/75 (63%)	35/60 (58%)	11	7/11 (64%)	7/10 (70%)	66/70 (94%)
■ III (Primary sacral tilt, sacral base unleveling only)	70	41/70 (59%)	25/52 (48%)	4	3/4 (75%)	3/4 (75%)	54/56 (96%)
■ IV (Contralateral tilt, unleveling of opposite sides)†	19	7/19 (37%)	3/14 (21%)	8	7/8 (87%)	4/7 (57%)	18/21 (86%)
Total	**365 (89%)**	**181/290 (62%)**	**114/203 (56%)**	**44 (11%)**	**23/38 (60%)**	**18/30) (60%)**	**205/238 (86%)**

* Delta (Δ) used as prefix to indicate the relative quantitative difference on the low or short side; LLI, leg length inequality.
† For the group with type IV, Δ LLI right will refer to Δ sacral base unleveling right, which means that the sacral base is significantly low on the patient's right side.

ment plans for patients with LBP. The following specific questions need to be addressed: How often is a Δ FHU due to asymmetric foot pronation or pes planus? How does foot flair correlate with LLI? Are occurrences of type I somatic dysfunctions uncommon, as Mitchell suggests,[32] or are they commonplace? Finally, is there a causal association between LLI and cranial patterns of somatic dysfunction, or vice versa?

Osteopathic medical theory has evolved in tandem with, but a step behind, actual practice, with osteopathic physicians re-creating specific techniques and rationales that complement their strengths and biases, allowing intuitional understanding of common compensatory patterns to marry with good intent. This intuitional understanding assured survival and growth of the osteopathic medical profession but was accompanied by an increasing number of osteopathic physicians who were unable to generate practical manual skills intuitively in the absence of a coherent theoretic basis for understanding common compensatory patterns.

Part 2 will explore the correlation of the frequency of scoliosis with pelvic type, Δ LLI, and age. In societies where an ever larger portion of the population spends an ever larger part of the day in the seated position, a practical, reproducible measure of postural asymmetry in the seated position seems necessary. Therefore, part 2 will introduce the seated hemipelvis and standing hemipelvis dependent variables and correlate them with pelvic group and frequency of scoliosis. In part 3, a series of clinical vignettes explore the usefulness of seated hemipelvis and standing hemipelvic measurements.

Lloyd and Eimerbrink's classification system is arbitrary and does not confer any functional predictive value. Just as earlier Papanicolaou smear systems were replaced by the Bethesda system, which provided useful information in terms of prognosis or treatment choice, frontal plane pelvic postural asymmetry could be reclassified into a more functionally oriented clinically predictive system. This may be addressed in part 4.

Comment

In this consecutive case study of 421 patients with LBP, most had a significant LLI, and most of those with LLI had a short leg on their dominant hand side. Using a 4-mm cutoff for LLI, the most common pattern of pelvic postural asymmetry is type I; the rarest is type IV. As the cutoff for Δ LLI increases to 10 mm and 15 mm, the type IB pattern predominates, and the type II pattern becomes extinguished.

As the cutoff for LLI increases, the frequency of SBU increases, with functional scoliosis tending to be convex to the Δ SBU. There is no age-dependent progression from one pelvic type to another. The frequency of sacral dysfunction, represented by the functionally similar type IB and type III groups combined, remains constant through the age spectrum.

In patients with a type IV pelvic postural pattern, scoliosis tends to follow the Δ SBU. A disproportionately large number of patients in the left-handed group had a type IV pelvic pattern.

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