Co-variables to unloaded leg-length alignment asymmetry, or the functional “short leg”

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INTRODUCTION

In order to better understand the phenomenon of the anatomic short leg, data has been reported including right vs. left incidence (1) and magnitude differences (2), gender (3), height (4) and biomechanical effects (5). A more in-depth analysis of this data is presented in a recently published review of the anatomic short leg (2).

A commonly used exam in the manipulative arts is for a functional "short leg" (6,7), better described as unloaded leg-length alignment asymmetry (LLAA). Essentially, after following a specified procedure to assume a prone or supine position unloading the pelvis, the feet are examined, most often at the welt (heel-sole interface), for the presence of alignment asymmetry. A recent review explores LLAA in more detail (8). While one study of the general, non-clinical population did record some co-variables of subjects with and without supine LLAA (9), such data on clinical subjects has rarely been recorded and examined. This study was undertaken to collect and analyze co-variables on subjects in clinical settings with a presumed supine functional "short leg" (LLAA).

MATERIALS and METHODS

Data on patient gender, height, width across the pelvic crest, transverse tilt of the pelvis, side and magnitude of LLAA was collected from subjects in 5 practices. Each practice utilized the supine leg check which involves the following protocol: the subject stands at the end of the examination table which is covered with slick naugahyde, and then sits down. Using their arms the subject pulls themselves evenly towards the head of the table until just the ankles and feet extend off the table. The subject, with their head resting on a headpiece, relaxes. To perform the supine leg check, the examiner squats at the foot of the table, then lightly grasps and cups the heels of the subjects' shoes. The feet are then gently de-rotated and squared to remove any foot rotation asymmetry. The examiner compares the positioning of the subject's heel/sole interface from side to side. LLA asymmetry was then estimated, with less than 1/8" considered to be "even" as was the protocol described in the reliability study of Hinson and Brown (10).

The width of the pelvis at the iliac crests was obtained using an x-ray caliper. To examine the transverse tilt of the pelvis the subject stood facing away from the examiner and spread their feet 6-8 inches. A pelvic level device with a weighted gravity line superimposed on a scale in one degree increments was placed on the palpated superior aspects of the iliac crests. High side deviation, right or left, was noted and recorded.

After examination and analysis of the data, a second set of data was obtained from n=30 patients in one practice. In this test, the patients were given a scale rated 0-10 and asked to indicate how far “out of alignment” they felt. Marked on the scale were the following indicators:

0 = I’m not having trouble now, just looking to get checked.

1 = I think I may be out of alignment, but am not sure.

5 = I’m sure that I am out of alignment, and need treatment.

10 = I feel like I am WAY out of alignment.

After filling out the scale, the examiner, blinded to the rating, examined the subject for supine LLAA, recording side and magnitude.

RESULTS

The demographic and exam data was obtained on n=155 subjects, 97 female, and 58 male, with a mean age of 46.9 years (SD 13.4). Mean height (n= 95) was 67.0 in (SD 4.6). Width across the pelvic crest (n=139) was 12.3 in (SD 1.48). Transverse plane pelvic tilt (n=95) found 48 (45.6%) with a right high, 36 (34.2%) with a left high iliac crest and 11 (10.4%) with an no transverse tilt. LLAA was more frequent on the right n=80 (52%) than the left n=75 (48%). The magnitude of LLAA on the right was 0.453 in. (SD 0.18), left was 0.385 in (SD 0.18). The magnitude difference between the sides of 0.068 in (just over 1/16”) was significant (2-tailed t-test, p=0.021).

The co-variables of gender, age, height, width of the pelvis across the iliac crest, tilt of pelvis in the transverse plane, side of LLAA on a supine leg check, and the magnitude of the LLAA were analyzed using Pearson’s correlation value (Table 1). The highest correlation was between gender and height, r = -.764 (males were taller than females). There was a fair positive relationship (r = 0.324) between pelvic width and magnitude of LLAA, and a fair negative relationship (r = -0.332) between pelvic tilt and the side of LLAA.

In the second data set of n=30, there were 18 females and 12 males with a mean age of 45.4 (SD 13.1). The mean height in this group was 67.6 in. (SD 4.7). Pelvic width was 12.2 in. (SD 1.47). Pelvic tilt showed 16 (53%) high right, 7 (23%) high left and 7 (23%) even. LLAA magnitude was more frequent on the right n=16 (61%) than left n=10 (39%). The magnitude of LLAA on the right was 0.434 in (SD 0.13), left 0.35 in (SD 0.079). The mean "out of alignment" rating was 5.6 (SD 3.0). A comparison (2-tailed t-test) between the original vs. follow-up groups for age, height, pelvic crest width, and LLAA magnitude found no significant differences between the two groups (Table 2).

The co-variables of gender, age, height, pelvic width, pelvic tilt, the presence and magnitude of LLAA, plus the "out of alignment rating" were again analyzed using Pearson's correlation value. The correlation between gender and height was, again, high at r= -.667. Pelvic tilt and side of LLAA was slightly more significant at r= -.466. The correlation between the magnitude of LLAA and "out of alignment" rating was high at r=.686.

DISCUSSION

Of the co-variables examined relative to unloaded leg-length alignment asymmetry, there was a fair, negative correlation of a high pelvic crest and the side of LLAA and a fair, positive correlation between the width of the pelvis and the magnitude of LLAA. A second, smaller study was done to examine the relationship between patient symptoms and the LLAA co-variables. There was a high positive correlation between how the patient rated their condition and the magnitude of LLAA.

In the larger study, the potential for error may come from the unequal contribution of co-variable data from each of the practices. However, no one co-variable was obtained from one practice only. This is not the case in the smaller study, and these findings need to be replicated. The second study does have the advantage of being blinded; the examiner did not know how the patient had rated their symptomatic involvement.

The correlation (r= 0.324) between pelvic width and magnitude of LLAA can be explained as a matter of biomechanics. Unloaded LLAA is suspected to result from hypertonicity of suprapelvic muscles 11-13. In a study of subjects with and without supine LLAA, those with LLAA had significantly decreased endurance times for the erector (Biering-Sorensen test) and quadratus lumborum muscles (14). Further, the side of LLAA significantly correlated with the side of the QL muscle quickest to fatigue. One of the causes of increased susceptibility of muscles to fatigue is hypertonicity. If LLAA is created by suprapelvic muscle hypertonicity, a wider pelvis should, hypothetically, be capable of creating a larger LLAA (Figure 1). While there was a correlation of these two co-variables, it was only fair. To explain this finding, it was reasoned that when there is a functional disturbance that creates a "short leg", this disturbance can be mild (giving a mild amount of LLAA), moderate or severe. As such, a wide pelvis with a mild functional disturbance might produce a mild LLAA, and not the full potential, large LLAA. On the other end, a small pelvis with a mild functional disturbance may not produce a visual LLAA at all.

This reasoning led to a hypothesis that the magnitude of LLAA could be affected by the degree of subjective symptoms. In other words, at some times a patient's symptoms may be more-or-less severe than at other times, and this may affect the magnitude of LLAA. Childs et al. have presented data that echo this notion, finding that self-rated VAS pain was positively correlated with asymmetric weight bearing 15. The greater the pain, the more asymmetric weight bearing/postural distortion.

Collecting data on self-rated symptomatic involvement along with the other co-variables might result in a clearer finding relative to any relationship between pelvic width, transverse plane unleveling and supine leg length alignment asymmetry. Pain was not used specifically as the rating criteria, as, in the authors clinical experience, some patients experience proprioceptive symptoms indicating a problem *prior* to the onset of pain. While technically ill-defined, the colloquialism, "out of alignment" was terminology coined, and understood, by patients.

The results of the second trial did demonstrate a high positive correlation (r=.686) between the blinded "out-of-alignment" rating and the magnitude of LLAA. This finding is evidence that LLAA is likely a functional problem, which changes with changing symptomatic intensity, and not anatomic anisomelia.

The potential interplay of the effects of anatomic and functional leg-length inequality may also explain some interesting findings. For example, we found a fair negative relationship (r = -0.332) between the high side of the (loaded or standing) pelvic tilt and the side of the (unloaded or supine) "short leg". Because anatomic LLI as well as functional LLAA could affect the standing pelvic level, this finding is not surprising, and is probably why Childs et al. found the same 16.

Another finding was of a greater magnitude of right (0.453 in) than left (0.358 in) supine inequality (1.73 mm) which was statistically significant (p=0.021, 2-tailed t-test). The anatomic right versus left leg difference is 0.85 mm, which is not statistically significant (p=0.08, t-test) (2). Why would the right leg tend to show a greater magnitude of asymmetry in functional LLAA?

One possibility is that, in performing the leg check, the examiner is exerting more pressure on one foot/leg over the other. One study has examined the pressure exerted through the long axis of the legs during functional leg checks, and did find slightly greater pressure being exerted by the examiners' right hand during the check (17). The authors speculated this may reflect the handedness of the examiner. Regardless, the slight increase in pressure from the dominant hand was not correlated with the side of perceived LLAA. Also, the data obtained in this study was collected from examiners who were right handed, which, in a supine leg check, would tend to exert more pressure on the left leg, not the right.

The reason for the larger magnitude of right side LLAA may relate to the interaction of an anatomic LLI with a functional LLAA. In anatomic LLI, the left leg is longer 53-75% of the time (2). This anisomelia affects the pelvic structure and tends to elevate the sacral base on the side of the long leg (18,19). The result of this compensation is to reduce the available range-of-motion of the L5/S1 joint on the long leg side relative to the short leg side (Figure 2). A subject with an anatomically longer left leg, in the presence of suprapelvic quadratus lumborum hypertonicity and given the biomechanics as outlined, is capable of a greater magnitude right LLAA than left. This confluence of anatomic and functional factors is a possible explanation for the finding of a greater magnitude right LLAA.

In reviewing these co-variables to presumed LLAA, some tentative recommendations and conclusions can be drawn. Pelvic unleveling is not a good indicator initial of a functional "short leg", as has been noted elsewhere (9,16). In an adult with a narrow pelvis, visualizing LLAA may be difficult, especially in combination with an anatomically long left leg. Both of these variables reduce available left side lumbopelvic lateral flexion and, potentially, the magnitude of LLAA. Given the correlation of pelvic width and patient symptoms to magnitude of LLAA, the supine test is likely demonstrative of a functional, not anatomic phenomenon.

CONCLUSION

This study collected and examined co-variables to suspect unloaded leg-length alignment asymmetry, or the supine functional "short leg". No firm conclusions can be drawn from one study, and the correlation between patient symptoms and supine leg-length alignment asymmetry magnitude needs to be confirmed. However, the data appears to indicate that certain anatomic and functional combinations may be responsible for false negative leg check findings, and that the supine "short leg" is a functional, not anatomic phenomenon.

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Table 1

Correlations

		Gender	Age	HipWd	PelvCrest	Height	LLAA mag	LLAA
Gender	Pearson	1	-.150	-.169(*)	.150	-.764(**)	-.068	-.144
	Sig. (2-tailed)	.	.063	.047	.146	.000	.398	.074
	N	155	155	139	95	95	155	155
Age	Pearson	-.150	1	.194(*)	-.116	-.051	.086	.043
	Sig. (2-tailed)	.063	.	.022	.263	.624	.285	.595
	N	155	155	139	95	95	155	155
HipWd	Pearson	-.169(*)	.194(*)	1	-.015	.046	.324(**)	.022
	Sig. (2-tailed)	.047	.022	.	.890	.671	.000	.798
	N	139	139	139	89	89	139	139
PelvCrest	Pearson	.150	-.116	-.015	1	-.188	-.281(**)	-.332(**)
	Sig. (2-tailed)	.146	.263	.890	.	.067	.006	.001
	N	95	95	89	95	95	95	95
Height	Pearson	-.764(**)	-.051	.046	-.188	1	.182	.109
	Sig. (2-tailed)	.000	.624	.671	.067	.	.077	.294
	N	95	95	89	95	95	95	95
LLAA mag	Pearson	-.068	.086	.324(**)	-.281(**)	.182	1	.184(*)
	Sig. (2-tailed)	.398	.285	.000	.006	.077	.	.022
	N	155	155	139	95	95	155	155
LLAA	Pearson	-.144	.043	.022	-.332(**)	.109	.184(*)	1
	Sig. (2-tailed)	.074	.595	.798	.001	.294	.022	.
	N	155	155	139	95	95	155	155

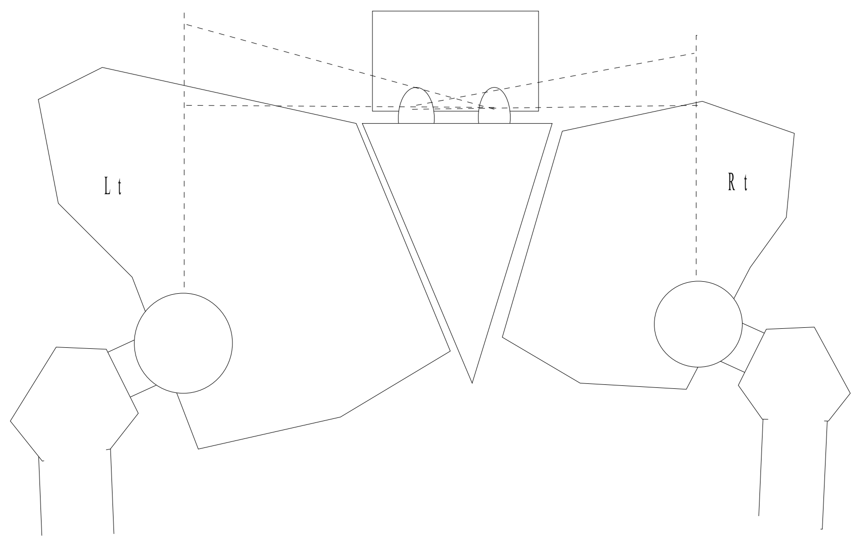
* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Table 2

Full group vs follow-up subject data	Group data	Follow-up data	t-test (2-tailed)
M/F%	38/62	40/60	
Age	46.9 (13.4)	45.4 (13.1)	p=0.55
Height	67.0 (4.6)	67.6 (4.7)	p=0.51
Pelvic crest width	12.3 (1.5)	12.2 (1.5)	p=0.15
Pelvic tilt R/L%	50/38	53/23	
LLAA R/L%	52/48	61/39	
LLAA R/L magnitude	Rt 0.45 (0.18) Lt 0.38 (0.18)	Rt 0.43 (0.13) Lt 0.35 (0.08)	p=0.65 p=0.55

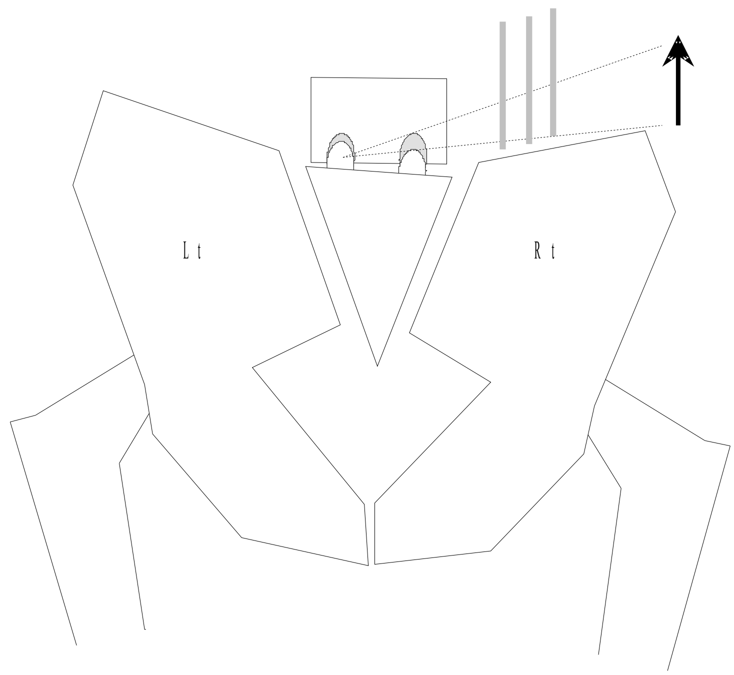
Numbers in ( ) are standard deviations.

Figure 1



With equivalent L5/S1 lateral flexion ROM, a suprapelvic load on a wider pelvis (Lt side) should produce a larger LLAA.

Figure 2



With a left long leg (which occurs ~64% of the time) the iliac crest and sacral base become unlevel - high on the long leg. The unlevel sacrum becomes laterally flexed relative to L5/S1, using up a portion of the facet ROM. For an average anatomic short leg (5 mm, or 3/16"), the amount of lateral flexion at the left L5/S1 facet is 1.5 degrees. This represents roughly one quarter of the amount of lateral flexion available. In an unloaded setting (supine/prone), suprapelvic load could produce greater movement on the right, making the magnitude of a right LLAA greater.