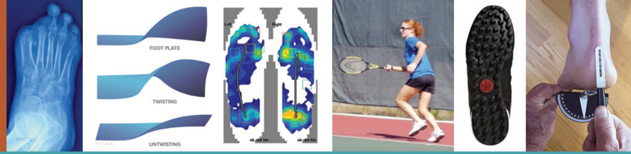

A Modern Approach to the Evaluation, Equalization, and Elimination of Limb Length Discrepancy

This is a common but frequently misdiagnosed condition.

BY JOSEPH C. D'AMICO, DPM, DSC

Goals and Objectives

- To review the importance and application of in-shoe pressure testing and temporal parameter analysis in the evaluation and equalization of limb length discrepancy
- To discuss the critical distinction between static and dynamic assessment
- To offer objective criteria and methodology to monitor and assess progress
- To illustrate the ability to recognize and eliminate functional asymmetry

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Introduction

Computer assisted gait analysis (CAGA) or in-shoe pressure testing has been available for use in a practice setting since the early 1980s. Michael Polchaninoff, DPM, an NYCPM orthopedic fellow, invented a compact, portable pressure testing system which Langer Biomechanics marketed as the Electrodynogram (EDG).[1-3] It became immediately apparent that this system enabled the unencumbered acquisition of gait data, which not only included foot pressure inside the shoe but temporal parameters as well. Before that time a patient had to visit a gait laboratory and walk over a force plate. This arrangement only captured force from the shoe to the plate, or barefoot to the plate.

Another problem was that the plate had to be targeted and, in most instances, only one step on one foot could be recorded at a time. Needless to say, individuals who were referred for this type of testing had significant and obvious gait abnormalities. With the advent of the Electrodynogram system, many more steps could be recorded in a realistic setting, i.e., inside the shoe and in a doctor's office. The data obtained proved to be repeatable, relevant, and reliable. The information it provided

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either affirmed or raised questions regarding the biomechanical and observational gait analysis findings.

In essence, this new technology revealed what actually takes place under the foot and inside the shoe while the subject is walking, which is quite different from what can be deduced from static and even dynamic clinical observations. A few major points that were now clearly elucidated included the fact that a clinically level pelvis does not ensure functional symmetry, and an uneven pelvis does not negate symmetrical function.

Figure 1: Thin, conformable, sensor imbedded insoles are trimmed to the subject's shoe and attached to an ankle connector

Furthermore, leveling the pelvis or "equalizing" limb length does not ensure functional symmetry and, in fact, may create pedal or limb imbalances manifested by asymmetrical plantar pressures as well as temporal parameter disturbances.[4-7] Also, many feet that had been asymmetrical in function were found to function symmetrically following the prescription of custom foot orthoses (CFO). Part of the reason for this frequently observed post-CFO symmetry is due to the fact that since no two feet are identical in size, shape, alignment, and function from right to left and now are individually and appropriately repositioned and restricted to a prescribed path of travel, the need for asymmetric, pathologic, compensatory adjustments are reduced, thereby encouraging more efficient and symmetrical performance.

In some cases, the corollary is also true: symmetrical but abnormal function without CFO was observed asymmetry following post-device dispensing testing. This is due to the inability of the foot to pathologically compensate for the discrepancy since it is now blocked from doing so by the device, in effect rendering it "uncompensated". In essence, the ultimate goal is to have both "wheels" spinning at the same speed, in proper alignment, traveling along the same correct path, for the same amount of time, and generating correspondingly equal pressures within acceptable ranges at each point in the gait cycle.

So, the question that begs to be answered is: if you don't have this information, how do you know? How do you know if the patient is functioning symmetrically and how do you know if what you're doing isn't creating asymmetry? Lack of symptoms is not a criterion for symmetrical function.

The Value of Computer Assisted Gait Analysis (CAGA)

The human foot performs distinct, repetitive, universal, sequential motions which have been able to be identified and charted. Since the foot functions in moveable segments, each segment must be in a specific ideal position on the ground and in the air at the appropriate time in the gait cycle. It is the direction and amplitude of pressure in a TIME context that must be addressed. How long is the part in contact with the ground? When did it reach its highest amplitude or peak? In what sequence was the force applied? And of particular relevance to this discussion, are these findings occurring symmetrically? These are some of the questions that are answered through the use of in-shoe pressure testing in the determination of foot and ankle functional status.

Figure 2: The cord from the ankle connector is attached to a small, unobtrusive, ergonomically designed waist pack recorder which is then remotely activated to begin a test

Computer assisted gait analysis allows the identification of "many more gait abnormalities".[8] In actuality, in-shoe pressure testing is not "gait analysis", which is the subjective and objective observation of body part movements (kinematics) and the forces and torques (kinetics) that accompany it, but rather a clinically applicable system of deductive and diagnostic logic using quantitative data obtained technologically and objectively in a realistic setting. The data represents an array of significant time and pressure events directly attributable to the functional activity of key foot segments.[2] It displays footprints in real time, force/time curves, and computes temporal parameters including stance, swing, double limb support, single limb support, speed, stride, and step length.[1,2,9-11]

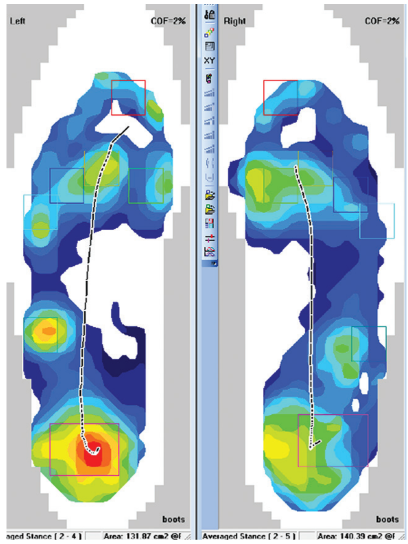

Figure 3: In-shoe averaged stance depiction of weight distribution patterns and center of pressure (COP) lines. Note the increased medial calcaneal pressure and longer COP line on the left foot in comparison to the right. The red and yellow areas indicate increased pressure.

CAGA also measures vertical ground-reactive forces and a center path of pressure (COP). It does not measure anterior and posterior or medial to lateral shear forces. If this informa-

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tion is deemed critical, force plate analysis would be required.

CAGA may clinically be utilized to influence and improve patient outcomes, expand existing knowledge, assist diagnosis, confirm clinical findings, understand etiology and progression, design and monitor treatment, and assess and improve performance. Specific applications may include the identification and management of limb length discrepancy, determination of hypermobility, the prescription and assessment of CFO, the identification and management of plantar pressures in the insensate foot, pre- and post-surgical intervention and procedure selection, management of stress fractures, predicting pathology, et al.[5,7,9-11]

Methodology

To begin a test, very thin, conformable, sensor embedded insoles are trimmed to fit into the patient's shoes. They are then attached to an ankle connector which feeds into an ergonomically designed, remotely activated, small recording pack which is then strapped around the subject's waist (Figures 1, 2). The sensors are actually time switches and scales reporting on stop/start events along with the corresponding pressure produced and the amount of time they are taking place. Tests are performed while the patient is walking barefoot, in most frequently worn daily footwear (sneakers, dress, and casual shoes). The patient is asked to walk at their own pace down a hallway that is recommended to be at least 24 feet long. The information that is obtained is recorded and downloaded, and the same procedure is performed for each situation that is to be assessed.

Total time for the average patient requiring three tests (daily footwear, sneakers, and barefoot) would be 20-30minutes. Once the information has been obtained, the patient is then disconnected from the recording apparatus and the findings are reviewed and presented to the patient, pointing out key points in each data section.

The average stance view is a particularly revealing two or three-dimensional graphic representation of the average pressure distribution through the foot for every step taken, excluding the first and last steps. (Figure 3). Other findings that may be discussed include path of pressure, captured two- and three-dimensional videos, patterns, time/force waveform comparisons, and temporal parameters. It has been my experience that patients are not only extremely interested and impressed in actually seeing how their feet are working but readily understand and appreciate the value of this information. Over the years, there have only been a couple of impatient patients who refused to perform or continue this testing, and this was due to the fact that multiple tests had to be performed to obtain the necessary data.

TAM Phases of Gait in % of Gait Cycle

Parameter	Normal Range	Left Foot Avg	Left Foot Variation	Left Foot StdDev	Right Foot Avg	Right Foot Variation	Right Foot StdDev
Stance	53 - 67	61	60 - 62	1	62	59 - 65	2
Swing	33 - 47	39	38 - 40	1	38	35 - 41	2
Contact	8 - 12	10	10 - 11	1	13	11 - 17	2
Foot Flat	9 - 12	23	21 - 27	3	14	12 - 17	2
Midstance	18 - 22	28	25 - 31	2	16	13 - 22	3
Propulsive	27 - 33	23	18 - 26	3	33	26 - 36	4
Active Propulsive	19 - 21	11	6 - 13	3	23	17 - 27	4
Passive Propulsive	8 - 12	12	11 - 13	1	10	9 - 11	1
Single Support	37 - 43	39	37 - 41	1	39	38 - 40	1
Total Double Support	16 - 24	22	21 - 23	1	23	21 - 26	2
Initial Double Support	8 - 12	10	10 - 11	1	13	11 - 17	2
Terminal Double Support	8 - 12	12	11 - 13	1	10	9 - 11	1
Cadence (steps/min)	90 - 120	94	-	-	94	-	-
Heel	50 - 62	59	55 - 68	5	42	37 - 55	7

Figure 4: Although there is an equal stance and swing phase bilaterally there is an increased foot flat, midstance and heel duration of 17% all greater on the left side along with an increased propulsive phase on the right indicating asymmetrical function.

Identifying Limb Length Discrepancy

Human gait requires the controlled loss and regaining of the center of gravity as it shifts from one base of support to another. For efficient locomotion, a symmetrical, well-aligned musculoskeletal system is necessary. In nature, gait symmetry is part of the overall design to minimize energy expenditure and improve muscular efficiency. Departures from efficient gait patterns such as that seen in functional asymmetry have an increased energy cost, along with accompanying stress and fatigue.

With symmetrical function and good alignment there is decreased energy expenditure and increased muscular efficiency, resulting in decreased stress and fatigue. Unfortunately, most of us are not structurally

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LONGER LIMB GAIT FINDINGS

- Increased midstance
- Increased heel contact
- Increased time (msec)
- Increased single support
- Increased medial calcaneal pressure
- Decreased propulsion
- Decreased steps per minute
- Decreased speed

Figure 5

SHORTER LIMB GAIT FINDINGS

- Decreased midstance
- Decreased heel contact
- Decreased time
- Decreased single support
- Decreased medial calcaneal pressure
- Increased propulsion
- Increased speed
- Increase steps per minute (spm)

Figure 6

Limb Length (from page 117)

or functionally symmetrical. Studies have shown that as much as 90% or more of the population has limb asymmetry.[5-7,12]

Limb length discrepancy (LLD) increases the potential for musculoskeletal pathology, especially when combined with limb pathomechanics. The average discrepancy is less than 1.1 cm and usually patients are easily able to compensate for this by either lengthening or shortening a limb, thereby minimizing their asymmetry.[13] However, even seemingly insignificant discrepancies may become symptomatic in stress situations such as running.

Historically, the gold standard for identifying a LLD has been standing radiographs.[14] Other methods include clinical measurements, asymmetrical examination observations, and indirect assessment by pelvic leveling.[5-7,10] No matter how revealing these static measurement methods findings may be, they do not reflect the pathomechanical impact of a suspected discrepancy during gait. The only way to objectively and realistically assess symmetry during function is through plantar pressure assessment testing. Functional limb symmetry or asymmetry following the use of CFO cannot be predicted and therefore should not be addressed until several weeks after dispensing.

Evaluation

The first step in assessing and obtaining functional symmetry is to negate all untoward musculoskeletal influences and deficiencies. This includes identification and neutralization of all abnormal pronatory and supinatory forces along with realignment of structural imperfections. This may include any or all of the following interventions: CFO, identification and stretch-

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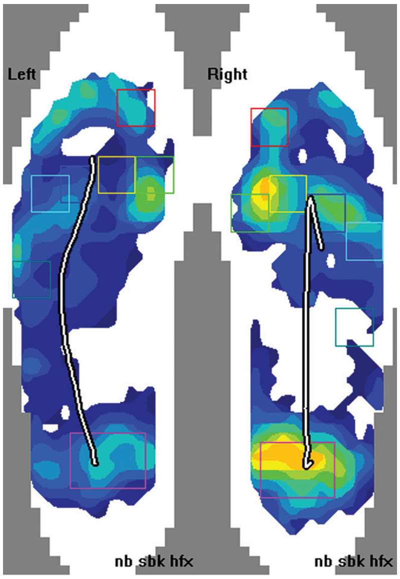

Figure 7: Averaged stance view revealing a laterally deviated COP on the left foot and central path on the right. There is an obvious increased medial calcaneal pressure on the right suggesting a functionally longer limb.

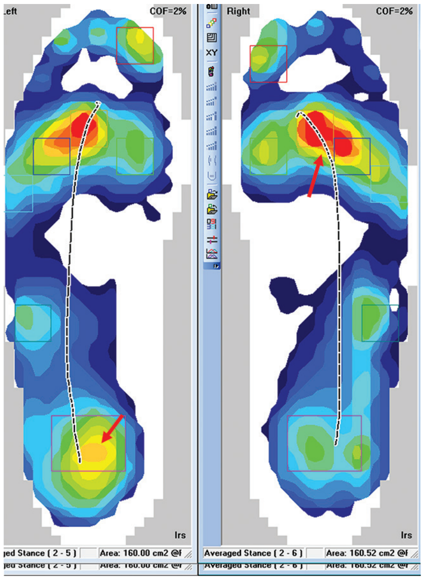

Figure 9: Averaged stance depiction of testing performed in rubber sole shoes revealing a longer COP line and medial calcaneal pressure on the left with increased pressure noted on the right 2,3 metatarsal heads indicating a shorter functioning right limb.

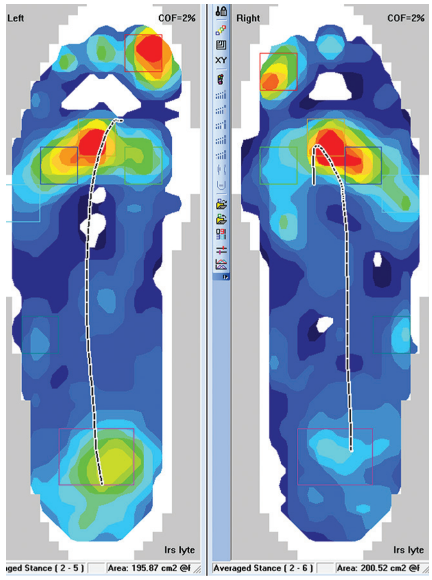

Figure 10: Testing in CFO depicts improved surface contact area, greater pressure left medial calcaneus and hallux. The longer left COP line remains.

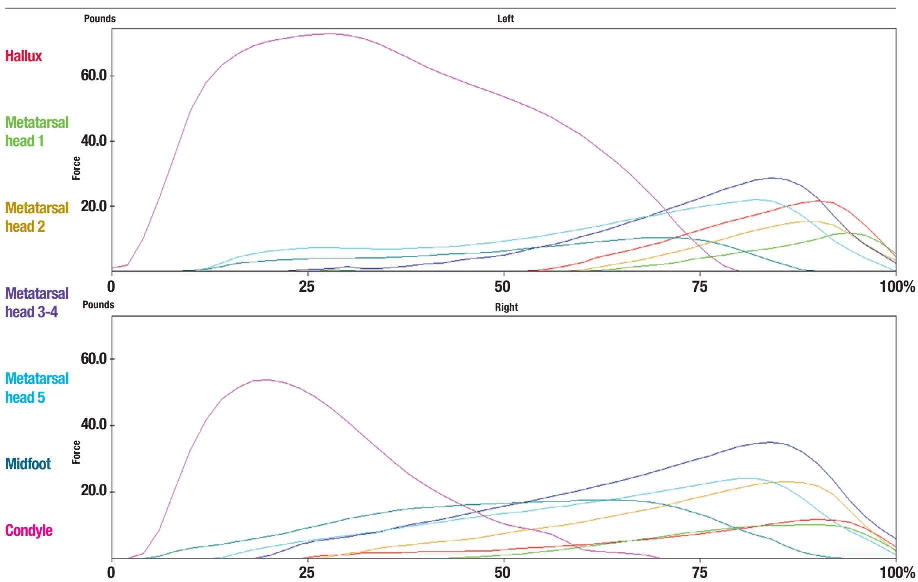

Figure 8: The force/time curves represent force applied over a period of time and should symmetrically resemble a double-humped or soft "M" shape with the heel (purple) representing the first mound and all the other colors representing different segments of the forefoot. The second propulsive phase waveform hump should be greater than the first in a normally functioning foot. Note the significantly longer heel duration and increased overall force on the left.

Limb Length *(from page 118)*

ing of posterior muscle group contractures, improving ranges of motion, strengthening of weak musculature, weight reduction (when appropriate), evaluating and remediating improper footwear, discontinuation of barefoot ambulation etc. Once all these untoward factors have been addressed, then assessing what's left is the next step in determining symmetry, and this is achieved through CAGA.

Dynamic assessment of functional symmetry is evidenced by symmetrical pressure mapping and timing comparisons during corresponding phases of the gait cycle. In the temporal parameters data section, important areas to evaluate include stance, swing, heel duration, time (msec), midstance, propulsion, initial and terminal limb support, and single support. In many cases, stance and swing phases are even; however, when one looks more closely at the stance phase of gait components, comparisons reveal underlying asymmetrical function (Figure 4). The foot functioning as a longer limb will display an increased heel duration, midstance, time, single support and initial double support, along with a decreased propulsive phase and a decreased number of steps per minute, with the shorter limb exhibiting the opposite findings (Figures 5, 6).[5-7,15]

An average stance depiction displays weight distribution patterns and a center of force line that should be appreciated (Figure 7). The longer limb characteristically displays a mid- to medial-directed center of pressure pathway and an increased medial calcaneal pressure, while the shorter limb exhibits the opposite findings.

A simplistic way to view this is to imagine the body vaulting over the longer side, thereby taking a longer time to do it, especially in the middle part of the high point of the path of travel. The body tries to shorten the longer limb by collapsing it as much as possible, thereby extending the contact and midstance phases, while at the same time slowing it down. This causes a medial shift in body weight, requiring increased muscular

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TAM Phases of Gait in % of Gait Cycle

Parameter	Normal Range	Left Foot Avg	Left Foot Variation	Left Foot StdDev	Right Foot Avg	Right Foot Variation	Right Foot StdDev
Stance	53 - 67	60	59 - 60	0	61	57 - 65	3
Swing	33 - 47	40	40 - 41	0	39	35 - 43	3
Contact	8 - 12	11	10 - 12	1	12	9 - 16	3
Foot Flat	9 - 12	24	19 - 29	4	19	15 - 24	3
Midstance	18 - 22	20	16 - 24	4	12	10 - 17	3
Propulsive	27 - 33	29	26 - 32	3	37	30 - 41	4
Active Propulsive	19 - 21	18	13 - 23	4	26	19 - 31	4
Passive Propulsive	8 - 12	11	10 - 13	1	11	10 - 12	1
Single Support	37 - 43	38	36 - 39	1	39	36 - 41	2
Total Double Support	16 - 24	22	21 - 23	1	23	20 - 25	2
Initial Double Support	8 - 12	11	10 - 12	1	12	9 - 16	3
Terminal Double Support	8 - 12	11	10 - 13	1	11	10 - 12	1
Cadence (steps/min)	90 - 120	100	-	-	100	-	-
Heel	50 - 62	47	42 - 54	5	34	30 - 41	4

Figure 11: Temporal data with CFO reveals reduced but still uneven midstance with greater propulsion on the right and a heel duration difference of 13% greater on the left.

TAM Phases of Gait in % of Gait Cycle

Parameter	Normal Range	Left Foot Avg	Left Foot Variation	Left Foot StdDev	Right Foot Avg	Right Foot Variation	Right Foot StdDev
Stance	53 - 67	61	60 - 63	1	61	59 - 69	4
Swing	33 - 47	39	38 - 40	1	39	31 - 41	4
Contact	8 - 12	12	11 - 13	1	11	9 - 16	3
Foot Flat	9 - 12	25	22 - 31	4	21	14 - 45	12
Midstance	18 - 22	19	13 - 25	5	16	11 - 30	7
Propulsive	27 - 33	30	25 - 35	4	34	22 - 40	6
Active Propulsive	19 - 21	20	13 - 25	5	22	13 - 26	5
Passive Propulsive	8 - 12	10	8 - 13	2	12	9 - 14	2
Single Support	37 - 43	39	38 - 41	1	39	36 - 43	3
Total Double Support	16 - 24	22	21 - 24	1	23	21 - 25	2
Initial Double Support	8 - 12	12	11 - 13	1	11	9 - 16	3
Terminal Double Support	8 - 12	10	8 - 13	2	12	9 - 14	2
Cadence (steps/min)	90 - 120	106	-	-	106	-	-
Heel	50 - 62	47	36 - 56	8	38	28 - 65	14

Figure 13: Temporal data with CFO plus ¼" right heel lift resulted in reduced and equal midstance phases, improved propulsive symmetry and a heel duration difference of 9%.

TAM Phases of Gait in % of Gait Cycle

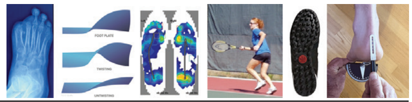
Parameter	Normal Range	Left Foot Avg	Left Foot Variation	Left Foot StdDev	Right Foot Avg	Right Foot Variation	Right Foot StdDev
Stance	53 - 67	61	60 - 64	2	62	60 - 66	2
Swing	33 - 47	39	36 - 40	2	38	34 - 40	2
Contact	8 - 12	11	11 - 12	1	12	10 - 15	2
Foot Flat	9 - 12	19	3 - 29	9	22	17 - 37	7
Midstance	18 - 22	26	16 - 46	10	20	13 - 26	5
Propulsive	27 - 33	23	7 - 32	9	31	25 - 37	5
Active Propulsive	19 - 21	12	-4 - 21	9	20	14 - 25	5
Passive Propulsive	8 - 12	10	7 - 12	2	11	11 - 12	1
Single Support	37 - 43	38	37 - 41	1	39	38 - 40	1
Total Double Support	16 - 24	23	21 - 24	1	23	21 - 26	2
Initial Double Support	8 - 12	11	11 - 12	1	12	10 - 15	2
Terminal Double Support	8 - 12	11	11 - 12	1	11	11 - 12	1
Cadence (steps/min)	90 - 120	101	-	-	101	-	-
Heel	50 - 62	55	41 - 79	13	44	[illegible]3 - 58	9

Figure 15: Temporal data with CFO and NO lift after 3 months revealed midstance greater on the left and propulsion greater on the right. Heel duration was 11%.

TAM Phases of Gait in % of Gait Cycle

Parameter	Normal Range	Left Foot Avg	Left Foot Variation	Left Foot StdDev	Right Foot Avg	Right Foot Variation	Right Foot StdDev
Stance	53 - 67	59	57 - 61	2	61	60 - 64	1
Swing	33 - 47	41	39 - 43	2	39	36 - 40	1
Contact	8 - 12	11	10 - 13	1	11	8 - 13	2
Foot Flat	9 - 12	29	21 - 33	5	29	22 - 40	7
Midstance	18 - 22	22	15 - 26	5	24	17 - 32	6
Propulsive	27 - 33	26	22 - 33	4	27	17 - 36	7
Active Propulsive	19 - 21	16	13 - 23	4	16	5 - 25	8
Passive Propulsive	8 - 12	10	8 - 11	1	11	10 - 13	1
Single Support	37 - 43	38	36 - 40	1	39	37 - 42	2
Total Double Support	16 - 24	21	20 - 24	2	22	19 - 25	2
Initial Double Support	8 - 12	11	10 - 13	1	11	8 - 13	2
Terminal Double Support	8 - 12	10	8 - 11	1	11	10 - 13	1
Cadence (steps/min)	90 - 120	104	-	-	104	-	-
Heel	50 - 62	51	37 - 57	8	51	36 - 68	12

Figure 16: Temporal data with CFO and the original ¼" lift reduced to 1/8" yielded symmetrical function in all phases of gait.



Limb Length *(from page 119)*

activity in an attempt to maintain stability in preparation for propulsion. On the shorter side, there's less limb to travel over, so it reaches its end quicker, thereby increasing pro-

Force/time waveforms exhibit characteristically asymmetrical configurations that are easily observable. These include an extension of the heel curve on the longer limb and an increased propulsive phase wave on the shorter limb (Figure 8).

either a 1/8" or 1/4" lift as indicated (Figures 9-13). Customarily, one may place lifts of up to 5/8" inside the shoe. Discrepancies greater than 3/4" will require a tapered extension to the forefoot of approximately half the amount of heel lift required. One

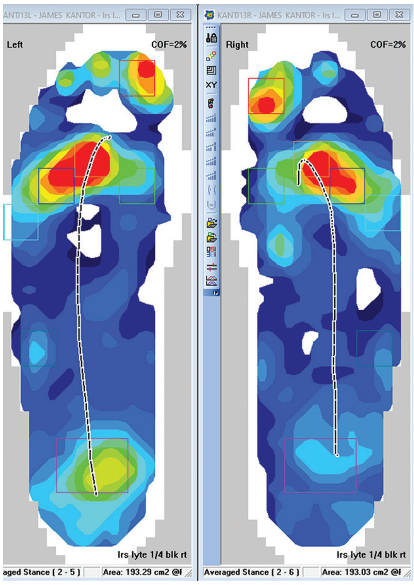


Figure 12: Averaged stance view wearing the CFO with a ¼" heel lift on the right resulted in reduced pressure on the right 2nd metatarsal head and medial calcaneus. Better symmetry in COP lines and hallux pressure were observed.

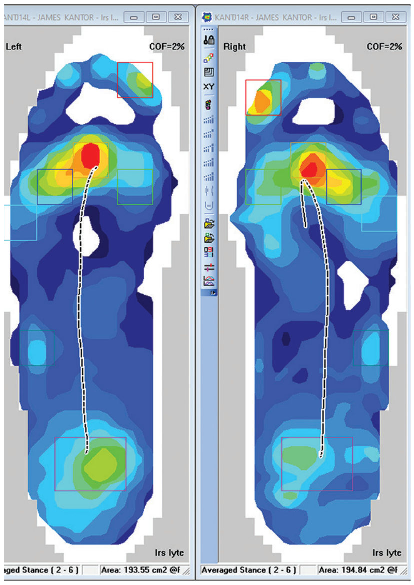


Figure 14: Averaged stance view with CFO and NO lift after 3 months reveals reduced pressure 2nd met heads and left medial calcaneus along with equal and borderline normal COP pathways.

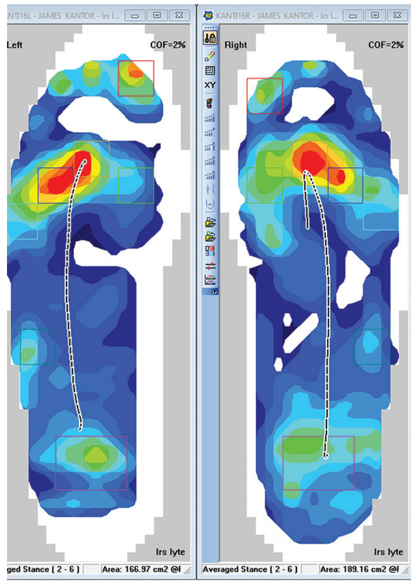


Figure 17: Averaged stance depiction CFO NO lift 6months post dispensing resulted in symmetrical and improved function in all phases of gait which was evidenced by symmetrical pressure mapping and equal, normal COP lines.

pulsion and diminishing any rear- and mid-foot delay. There may be a lateral "leaning" of the foot on the shorter side in an attempt to positionally "lengthen" the limb, thereby influencing its speed and path of travel (Figure 7).

TAM Phases of Gait in % of Gait Cycle

Parameter	Normal Range	Left Foot Avg	Left Foot Variation	Left Foot StdDev	Right Foot Avg	Right Foot Variation	Right Foot StdDev
Stance	53 - 67	59	55 - 62	2	60	58 - 62	2
Swing	33 - 47	41	38 - 45	2	40	38 - 42	2
Contact	8 - 12	9	7 - 9	1	12	11 - 15	2
Foot Flat	9 - 12	20	5 - 25	8	20	16 - 27	4
Midstance	18 - 22	20	18 - 24	2	17	12 - 20	3
Propulsive	27 - 33	31	26 - 35	3	32	27 - 35	3
Active Propulsive	19 - 21	19	15 - 24	3	23	18 - 26	3
Passive Propulsive	8 - 12	11	11 - 12	1	9	7 - 11	1
Single Support	37 - 43	39	34 - 42	3	39	38 - 42	1
Total Double Support	16 - 24	20	18 - 22	1	21	18 - 23	2
Initial Double Support	8 - 12	9	7 - 9	1	12	11 - 15	2
Terminal Double Support	8 - 12	11	11 - 12	1	9	7 - 11	1
Cadence (steps/min)	90 - 120	107	-	-	107	-	-
Heel	50 - 62	43	33 - 53	7	41	33 - 51	6

Figure 18: Temporal data CFO NO lift 6 months post dispensing exhibited equal and optimal foot flat, midstance, propulsion and heel duration thereby eliminating the need for a lift.

Equalization

In a computer-assisted gait analysis study of 17 individuals with an identified limb length discrepancy and unilateral musculoskeletal symptomatology, the addition of a 1/4-inch heel lift to the shorter limb resulted in 50 to 100 percent symptom improvement in all cases.[15] Additionally, the average cadence of 48.2 steps per minute on the longer side and 52.3 steps per minute on the shorter side improved to 44.0 steps/minute on the longer limb and 45.0 steps per minute on the shorter limb.

Once the LLD is identified, begin testing with may also reduce the heel or remove the shoe insole on the longer limb to achieve symmetry. Discrepancies up to 7/8" may be equalized in this manner without having to conspicuously alter the short limb shoe. To obtain functional symmetry, most individuals respond well to 1/8", 1/4" or 3/8" lifts. It is less common for 1/2" lifts or greater to be necessary to achieve symmetry. In those individuals who are unresponsive to the addition of lifts even with increasing lift heights, re-assessment of sacroiliac and lumbosacral mobility is warranted.

Elimination

Lifts do not last forever. The amount of lift that is appropriate at the onset of treatment may not be what is required several months later (Figures 14-16). Periodic evaluation is necessary. I view the lift as a neuromotor reminder that each step should possess this path, sequence, timing, and pressure; thereby creating and

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embedding a new and correct response in the system. Once testing has determined that symmetry has been achieved, re-assessment is indicated in two to three months. Functional asymmetry tends to reduce over time with treatment (Figures 14-16).

This may be due to assimilation of the lift action into the musculoskeletal functional framework; thereby, in some cases, eliminating the need for any lift at all (Figures 17, 18). The bottom line is when a patient states, "Fifteen years ago, my doctor told me my right leg is shorter, so I have a lift built into all my shoes," that lift is not doing the same thing now as it did at the initial prescription. Many times, these have found to be either too much, too little, not needed, or on the wrong side.

Summary

Limb length discrepancy is a common musculoskeletal deficiency with widespread untoward effects. Historic methods to statically assess its presence do not address or take into consideration its dynamic requirements. Computer assisted gait analysis is a modern, non-invasive, objective, relevant, reliable clinical method useful in the evaluation, equalization, and elimination of limb length discrepancy. **PM**

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CME EXAMINATION

SEE ANSWER SHEET ON PAGE 121.

1) Who developed an in-shoe pressure testing system originally referred to as The Electrodynogram for use in clinical practice?
- **A) Verne Inman, MD**
- **B) Richard Schuster, DPM**
- **C) Merton Root, DPM**
- **D) Michael Polchaninoff, DPM**

2) What percent of the population has limb asymmetry?
- **A) 20%**
- **B) 40%**
- **C) 60%**
- **D) 90%**

3) What is the average limb length discrepancy?
- **A) 1.1 cm**
- **B) 1.9 cm**
- **C) 2.5 cm**
- **D) 3.0 cm**

4) Which of the following is true for the limb on the longer side?
- **A) Increased midstance**
- **B) Increased heel duration**
- **C) Increased time**
- **D) All of the above**

5) Which of the following is true for the limb on the shorter side?
- **A) Increased propulsion**
- **B) Increased speed**
- **C) Increased steps per minute**
- **D) All of the above**

Continued on page 122

Continuing Medical Education

CME EXAMINATION

(Continued from page 121)

6) In-shoe pressure testing measures which one of the following forces?
- **A) Vertical ground reaction forces**
- **B) Anterior-posterior shear**
- **C) Medial-lateral shear**
- **D) Friction**

7) Clinical applications of computer assisted gait analysis include which of the following?
- **A) Determination of hypermobility**
- **B) The identification and management of limb length discrepancy**
- **C) The identification and management of plantar pressures in the insensate foot**
- **D) All of the above**

8) What one of the following is the most important characteristic for efficient locomotion?
- **A) Muscular strength**
- **B) Range of motion**
- **C) Gait symmetry**
- **D) Flexibility**

9) An increased medial calcaneal pressure and a medially deviated center of pressure line on the left side and an increased lateral calcaneal pressure and lateral deviation of the center of pressure on the right side would indicate which one of the following?
- **A) Limb length discrepancy R short**
- **B) Limb length discrepancy L short**
- **C) Normal variation**
- **D) None of the above**

10) When comparing right and left gait analysis test data which one of the following would be the LEAST reliable indicator of asymmetrical function?
- **A) Stance and swing phase**
- **B) Midstance**
- **C) Heel duration**
- **D) Propulsion**

SEE ANSWER SHEET ON PAGE 123.

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EXAM #8/24
A Modern Approach to the Evaluation, Equalization, and Elimination of Limb Length Discrepancy (D'Amico)

Circle:

1.	**A**	**B**	**C**	**D**	**6.**	**A**	**B**	**C**	**D**
2.	**A**	**B**	**C**	**D**	**7.**	**A**	**B**	**C**	**D**
3.	**A**	**B**	**C**	**D**	**8.**	**A**	**B**	**C**	**D**
4.	**A**	**B**	**C**	**D**	**9.**	**A**	**B**	**C**	**D**
5.	**A**	**B**	**C**	**D**	**10.**	**A**	**B**	**C**	**D**

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Strongly agree [5]	Agree [4]	Neutral [3]	Disagree [2]	Strongly disagree [1]

1) This CME lesson was helpful to my practice ____

2) The educational objectives were accomplished ____

3) I will apply the knowledge I learned from this lesson ____

4) I will makes changes in my practice behavior based on this lesson ____

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6) What overall grade would you assign this lesson?

A B C D

7) This activity was balanced and free of commercial bias.

Yes _____ No _____

8) What overall grade would you assign to the overall management of this activity?

A B C D

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____

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