Metatarsus Primus Supinatus. *Its Etiology, Biomechanical Impact and Treatment*

By

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ABSTRACT

Rothbart is the first to describe a foot in which the 1st metatarsal is structurally elevated and inverted relative to the 2nd metatarsal. He terms this foot structure Primus Metatarsus supinatus (PM*s*).

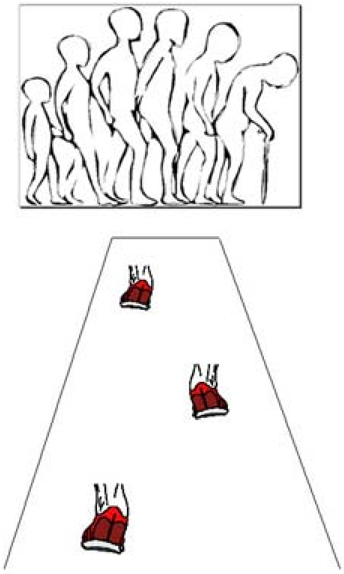
In this position paper, Rothbart links the etiology of PM*s* to an incomplete unwinding of the talar head. A procedure for measuring PM*s* is presented: maintaining the foot in its anatomical neutral position, the distance between the ground and 1st metatarsal is determined. This measurement represents the PMs value. PM*s* values between 10mm and 25mm are pathognomonic for the Rothbart Foot Structure (RF*s*).

Rothbart Foot structure is biomechanically dysfunctional, demarcated by a prolonged mid-stance hyperpronation pattern. This pathodysfunctional foot orchestrates a predictable postural shift, foot to jaw: (1) Unleveling of the pelvis {pelvic tilt}, (2) protraction of the shoulders, and (3) anterior displacement of the head relative to the cervical spine. Postural muscles tend to become tight (braced) and painful. Published studies have demonstrated a consistent link between this postural shift and the development of chronic pain conditions.

An innovative proprioceptive insole is described that attenuates hyperpronation resulting from RF*s*. Forward postural shifts are reversed which, in turn, facilitates the long-term resolution of chronic pain conditions.

INTRODUCTION:

Rothbart (1) was the first to describe a foot in which the 1st metatarsal is *structurally elevated and inverted* relative to the second metatarsal. Referred to as Primus Metatarsus {Elevatus} Supinatus (PM*s*), this foot type is *visually* identified by its deep 1st webspace (**See Figure 1)**. PM*s* is biomechanically dysfunctional, delineated by its prolonged phase of mid-stance hyperpronation. But what forces this foot to hyperpronate? And what impact does this hyperpronation have on posture?



Rothbart contends that as the body's weight passes over the inner longitudinal arch, GRAVITY pulls the forefoot forward, downward and inward (hyperpronates) until the 1st metatarsal reaches the ground. This protracted phase of hyperpronation, gradually and progressively overtime, 'powers' a forward postural shift foot to jaw (**See Figure 2)**. Johnson (2) describes this shift in posture as a series of common compensatory patterns in which [a] the left PSIS is anterior and superior relative to the right PSIS (i.e., pelvic tilt), [b] the ribcage is rotated counterclockwise, [c] the left shoulder is protracted {forward} and superior {higher} relative to the right shoulder, and [d] the head is anteriorly displaced (shifting the maxilla forward), resulting in a Class II dental occlusion, or overjet bite (3). This overall postural shift is referred to as BioImplosion (4). Rothbart (5,6,7) has demonstrated a consistent link between BioImplosion and the development of chronic pain conditions, foot to jaw (**See Table 1**).

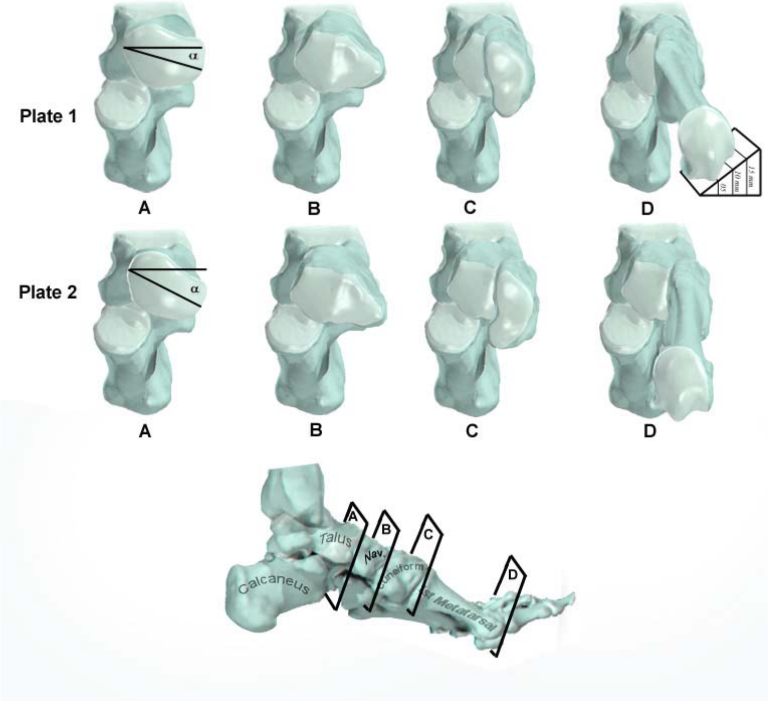
Plantar Fasciitis
Oblique patellar tracking pattern (chondromalacia)
Sacral iliac joint inflammation
Low back pain
Thoracic outlet syndrome
Tension Headaches
Temporal mandibular joint dysfunction

Table 1. Chronic Pain Conditions Associated with BioImplosion

Section 1 of this paper {Etiology of PM*s*} delineates the torsional events that result in PM*s*. Section 2 {PM*s* Clinically} describes (1) a methodology for diagnosing PM*s* and (2) its impact on foot function and posture. Section 3 {TREATMENT OF PM*s*} describes an innovative proprioceptive insole in the treatment of PM*s*.

ETIOLOGY OF PMS

Measuring 1006 Egyptian Feet, Sewell (8) reported substantial variances in the shape of the talus (∠α) (**See Figure 3**, Plate 1A & Plate 2A). Straus (9) reported ∠α*s* ranging between 26 and 43 degrees, McPoil (10)



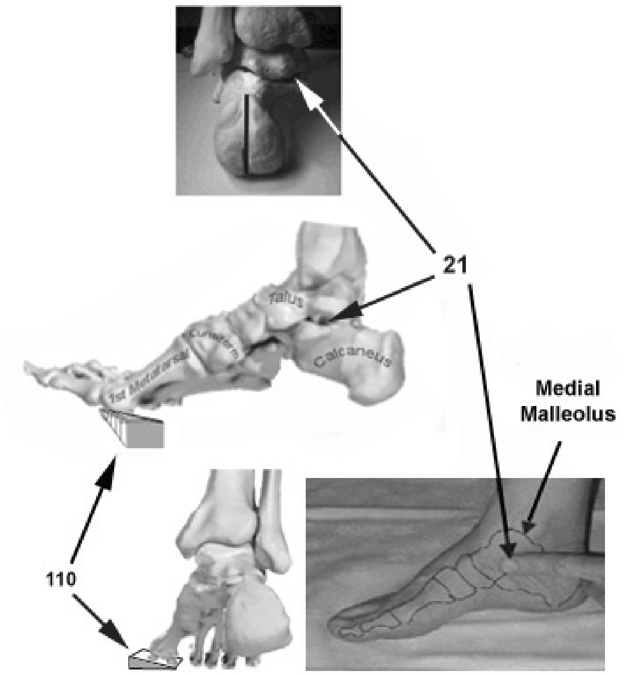
between 24 and 51 degrees and Sarrafian (11) between 30 and 65 degrees. This torsion or twist within the talar head (termed **talar torsion**) orchestrates the shaping of the medial column of the foot, navicular to 1st metatarsal (12,13,14): As the fetus develops, if the talar head remains in supinatus (lower $\angle\alpha s$), the navicular remains in relative supinatus (**See Figure 3**, Plates 1B). If the navicular remains in supinatus, the internal cuneiform remains in relative supinatus (**See Figure 3**, Plate 1C). Rothbart (15) asserts that medial column supinatus places the 1st metatarsal and hallux in relative supinatus (inverted and elevated) (**See Figure 3**, Plate 1D). In the adult foot, this structural supinatus of the 1st metatarsal is termed Primus Metatarsus *s*upinatus (PM*s*).

PM*s* appears to be an atavism (throwback) to the chimpanzee's foot in which the big toe functions as a prehensile appendage, a classic example of ontogeny recapitulating phylogeny (16,17,18).

PMS CLINICALLY

DIFFERENTIAL DIAGNOSIS [MEASURING] PM*S*

Patient Standing, Vision Straight Forward - Locate the medial talocalcaneal (subtalar) joint. This easily palpable joint is approximately one finger width below and in front of the medial malleolus (**See Figure 4** –21). Keeping your finger on the medial subtalar joint, have your patient slowly rotate their hips, first counterclockwise and then clockwise. This will pronate (evert) and supinate (invert) the right foot respectively. Guide the right foot through this range of motion until the upper and lower margins of the subtalar joint feel congruous (parallel) to one another. This is the anatomical neutral position of the subtalar joint (**See Figure 4**, top photography). If the subtalar joint is pronated or supinated, the joint space will feel collapsed (obliterated) or cavernous respectively. While maintaining this STJ *n*P, slide a microwedge (**See Figure 4** -110) underneath the 1st metatarsal head until slight resistance is encountered from the bottom of the foot. Record the PMs value (vertical displacement between the 1st metatarsal head and ground). Repeat this protocol for the left foot. PMs values between 10 and 25 mm define the Rothbart Foot Structure (RFs).



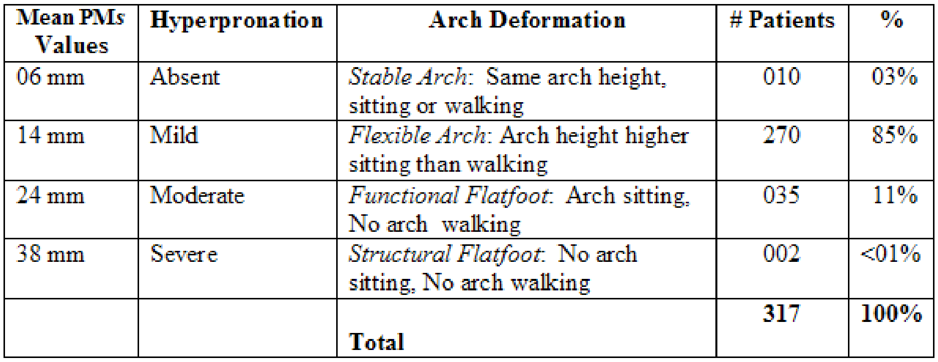
This measuring technique has proven to have high inter-relater reliability. For example, at the Annual Conference of the American Academy of Pain Management in Dallas (19), 125 healthcare providers were divided into 5 groups, each group having 25 members. Each group then randomly selected two members, one acting as group leader, the other to be measured (left foot only). In this single blind study, measurements taken by the group leaders were sequestered from the group members. Results: In each group, all measurements (115 in total) were within ± 2mm of the value recorded by their respective group leader, well within an acceptable variance when fitting proprioceptive insoles.

In the young pediatric foot, the bulging longitudinal fat pad and malleability of the tarsal bones makes it difficult to ascertain the presence of PM*s*. However, by age 4 the inner longitudinal arch (ILA) has ossified into its adult shape (20,21,22,23). This substantially facilitates the process of measuring the foot.

Clinical Significance of PMs

In the adult foot {age 4 and over}, PM*s* values over 10mm identify a biomechanically unstable (hyperpronating) foot. Inman defines normal pronation as that degree of pronation generated by the internal transverse plane oscillations of the hips (24) (**See Figure 5**). Clinically this pronation pattern is invisible, e.g., the ankle remains visually stable (vertical) throughout the entire stance phase of gait. Conversely, any degree of ankle twist noted during stance phase of gait is, by definition, hyperpronation.

In a clinical (25), 317 chronic pain patients were categorized into 1 of 4 groups based on their arch type (stable, flexible, functional and structural) (**See Table 2**). Visual gait analysis was conducted on each group by 3 independent observers. A subjective scale was used in judging the degree of dynamic hyperpronation (absent =1/mild =2/moderate =3/severe =4). The scores were mathematically compiled and an average computed for each group (reported under the heading hyperpronation). PMs readings were then taken by the author on each of the 317 individuals and mean values calculated for each group. Results: This study suggested that as PM*s* values increased, foot



Mean PM*s* Values	**Hyperpronation**	**Arch Deformation**	**# Patients**	**%**
06 mm	Absent	*Stable Arch*: Same arch height, sitting or walking	010	03%
14 mm	Mild	*Flexible Arch*: Arch height higher sitting than walking	270	85%
24 mm	Moderate	*Functional Flatfoot*: Arch sitting, No arch walking	035	11%
38 mm	Severe	*Structural Flatfoot*: No arch sitting, No arch walking	002	<01%
		Total	**317**	**100%**

Table 2. PM*s* values vs. hyperpronation and arch stability in chronic pain patients.

hyperpronation increased. An unanticipated outcome was the frequency PMs values above 10 mm (307/317 patients). However, this was attributable to the skewed sample: only patients with a chronic history of intractable musculoskeletal pain.

PM*s* values >10mm significantly force the walking foot to roll inward, forward and downward {hyperpronate typically left > right} until the 1st metatarsal rests on the ground. This shifts the body's center of gravity forward and downward, which in turn, pulls the innominates forward and downward {typically left > right}. The pelvis is unleveled, resulting in a functional leg length discrepancy {left longer than right}. As these displacements cascade up the axial framework, scoliotic and kyphotic curves are exaggerated, the shoulders protract. The head and upper teeth move forward. This gravity-induced skeletal 'collapse' (termed BioImplosion) can initiate musculoskeletal problems, foot to jaw. For example, a chronic shoulder protraction or pelvic tilt can lead to a functional thoracic outlet syndrome or sciatica respectively.

PMs values > 10 mm frequently result in adaptations or compensations within the postural muscles, ranging from bracing to releasing. Clinically, shoe wear patterns and relative arch shape (non-weight bearing) demarcate bracers from releasers: Bracers wear down the outer middle to outer margins of the heels and tend to have fairly high arches. Their postural muscles tend to be tight and painful. Releasers wear down the inner middle to inner margins of the heels and tend to have fairly low arches. Their postural muscles tend to be looser and not as painful as bracers. Bracers are more common than releasers and tend to develop symptoms related to their increased tonicity in the postural muscles (e.g., tension generated headaches). Releasers frequently manifest articular symptoms resulting from abnormal shear or torsional forces (e.g., oblique patellar tracking syndrome or hallux abductovalgus). In general, bracers require a more conservative approach than releasers. Interesting enough, this author has noted a correlation between bracing/releasing patterns and personality types: Bracers tend to be *Type A* personality, Releasers *Type B* personality.

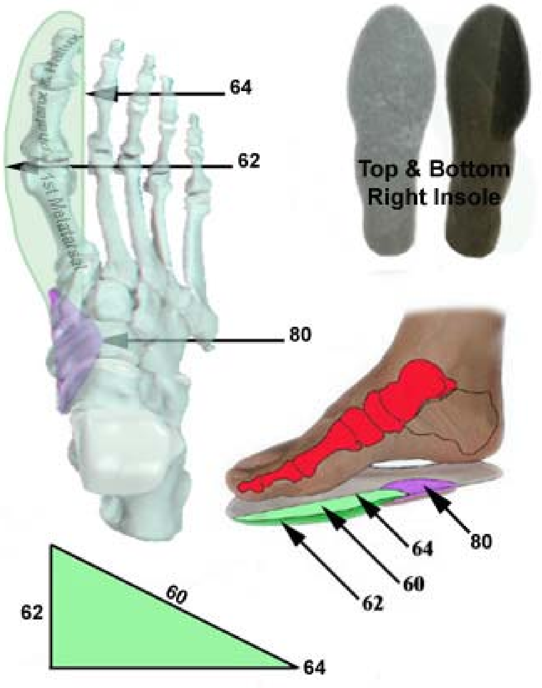
TREATMENT OF RFs (PMs values between 10 and 25 mm)

HEEL WEDGES AND ARCH SUPPORTS

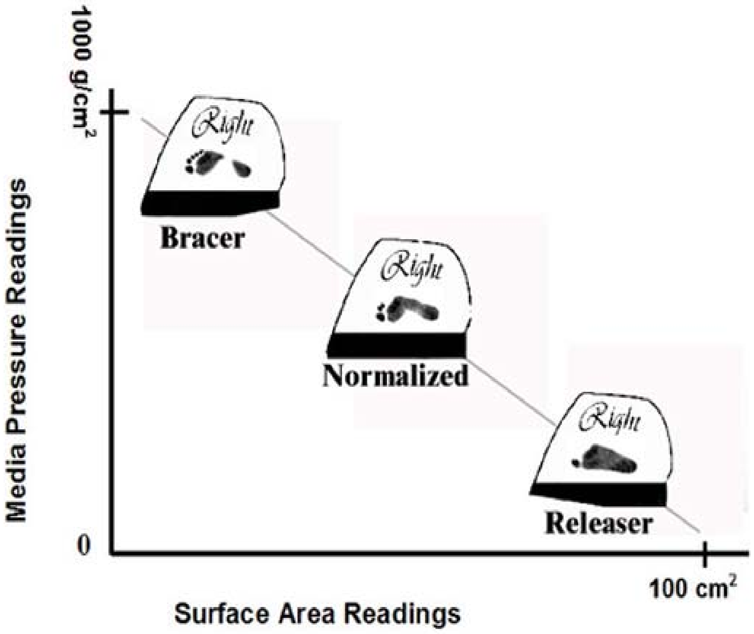
Medial heel wedging visibly decreases standing hyperpronation. However, it also increases functional PM*s* values, which in turn, increases dynamic hyperpronation. (Wedging the inside of the heel bone functionally increases the distance between the 1st metatarsal and ground. In essence, PM*s* values are augmented.) Arch supports decrease midstance hyperpronation, but are ineffective as the forefoot engages in weight bearing. Paradoxically, arch supports affect feet like immobilization casts affect muscles: function is improved at the price of muscle strength. In time, these same feet become weaker/more pronated (when barefooted) than they were prior to arch support therapy.

PROPRIOCEPTIVE INSOLES

Proprioceptive insoles do not support the foot. They do not wedge or cup the heel (**See Figure 6**). These innovative insoles function as a tactile stimulant to the bottom of the 1st metatarsal head and big toe of the foot. Interesting enough, in terms of foot mechanics, this occurs through kinesthetic



reposturing (26, 27, 28). With each step, the foot is reminded where it should be {not here, but over there) and automatically makes the adjustment. Hyperpronation is reduced which shifts the body's center of gravity posteriorly. The pelvis becomes *visually* more vertical (tucked). The shoulders retract. And the head tends to be more centered over the spine. Tonus in the postural muscles becomes more normalized. This is demonstrated using the Midicapteur's Podolab 2000® electronic pedometer (29): [1] Wearing shoes, the patient walks for 5 minutes. [2] Standing *barefooted* on the pressure plate, *S*urface *A*rea and *M*edia *S*urface *P*ressure Readings are recorded. [3] Fitted with proprioceptive insoles, the patient walks for another 5 minutes, [4] Again standing *barefooted* on the pressure plate, a second set of *S*urface *A*rea and *M*edium *S*urface *P*ressure Readings are taken. This set of readings is compared to the first set of readings. Effective insole therapy normalizes *SA*-Rs (foot shaping) and *MSP*-Rs (postural tonus). In *bracers*, *SA*-Rs increase (↓ pes cavus), *MSP*-Rs decrease (postural tonus normalizes, foot to jaw). In *releasers*, *SA*-Rs decrease (↓ pes planus), *MSP*-Rs increase (postural tonus normalizes, foot to jaw) (**See Figure 7**). Ineffective insole therapy skews these readings.



The *empirically derived* rule of thumb is 30% tactile STIMULATION = 70% improvement (30). (This rule of thumb was calculated from a study involving 317 patients and may require adjustment as further data is compiled.) For example, a 6mm proprioceptive insole under a foot measuring 20 mm tends to decrease the observable hyperpronation by approximately 70%. If this 30-70% rule of thumb is ignored, and more aggressive geometry is used (e.g., a 9mm proprioceptive insole in a bracer measuring 15mm), tension and/or pain frequently exacerbates in the postural muscles (e.g., trapezius or sternocleidomastoides). Concurrently, media pressure readings increase. Apparently, the foot can accept only so much tactile input before the postural muscles react negatively.

An unexpected outcome using foot tactile systems is the observation that braced (hypertonic) muscles can become disassociated from the foot. That is, these neuromuscular trigger points can evolve into self-perpetuating loops. The associated pain referral patterns prove intractable to foot therapy alone. This underscores the importance of concurrent foot and soft tissue therapy when dealing with chronic pain conditions.

Dimensioning proprioceptive insoles as a supportive device (e.g., dimensioned at 100% of the measured PM*s*) tend to weaken the foot and accelerate the process of BioImplosion. Using proprioceptive insoles in ***non***-RF*s* places a disruptive upward load on the 1st metatarsal head. This can dramatically limit the range of dorsiflexion within the 1st metatarsal-phalangeal articulation and lead to a functional hallux limitus.

SUMMATION:

Lower $\angle\alpha s$ results in Primus Metatarsus *s*upinatus. Functionally, gravity pulls the elevated and inverted 1st metatarsal into significant hyperpronation. Published studies have linked foot hyperpronation to BioImplosion, and BioImplosion to chronic pain syndrome.

Measuring supinatus at the level of the 1st metatarsal head facilitates a differential diagnosis. PM*s* values of 10mm – 25mm define the Rothbart Foot *s*tructure.

Using proprioceptive insoles, PM*s* is effectively stabilized. Dimensioning these insoles at 30% of the measured supinatus *tend* to visually decrease the excessive hyperpronation by approximately 70%. This in turn reduces pelvic tilts and shoulder protractions. As posture becomes more vertical, treatment of intractable musculoskeletal dysfunctions become more amendable to long-term resolution.

Captions for Figures 1 – 7

Figure 1. *Deep 1st Web Space*. The 1st metatarsal is shorter than the 2nd metatarsal creating the deep 1st web space. This relative shortness of the 1st metatarsal frequently occurs in the Rothbart Foot Structure.

Figure 2. *Postural Shift Associated with Hyperpronation.* BioImplosion (upper diagram) is a gravity induced postural shift powered by dynamic foot hyperpronation (lower diagram). As the foot rolls inward, downward and forward (hyperpronates), the entire postural axis shifts inward, downward and forward.

Figure 3. *Torsional Development of the Medial Column of the Foot.* [Sectional Views, Frontal Plane] Lower $\angle\alpha$s are linked to Primus Metatarsus Supinatus. Supinatus of the talar head maintains the *entire* medial column of the foot remains in supinatus. Plate 1A illustrates Talar Supinatus, Plate 1B Navicular Supinatus, Plate 1C Cuneiform (Internal) Supinatus, and Plate 1D Metatarsal Supinatus and Microwedge. Higher $\angle\alpha$s are linked to the plantargrade position of the 1st Metatarsal. The unwinding of the talar head, 'directs' the unwinding of the entire medial column of the foot, navicular to hallux (See Plates 2A –D).

Figure 4. *Measuring PMs* [Right Foot] Refer to Differential Diagnosis for the clinical protocol in taking this measurement.

Figure 5. *Transverse Plane Oscillations of the Pelvis*. (Downward, Transverse Plane View of the Lower Body) As the left leg is swung forward, the left innominate rotates inwardly on the transverse plane, and with it, the left femur and tibia. The internal rotation of the left tibia pronates the weight-bearing left foot. This mechanical link between the subtalar joint and pelvis defines normal pronation: *pronation generated by the internal transverse plane oscillations of the pelvis*. Pronation generated by the elevated 1st metatarsal, is abnormal (hyper) pronation.

Figure 6. *Proprioceptive Insoles*. Manufactured by Postural Dynamics Incorporated, Seattle Wa, http//www.PostureDyn.com (upper right photograph). The positioning of the proprioceptive insole is demonstrated (middle right drawing): 60 represents the sloping surface of the appliance. 62 represents the medial margin of the appliance (maximal tactile input). 64 represents the lateral margin of the appliance (minimal tactile input). Arch supports (80) are used in functional flatfeet where the structural integrity of the talonavicular joint is severely compromised.

Figure 7. *Bracer vs. Releaser.* The plantar surfaces of the 1st metatarsal, proximal phalanx and hallux act like a rheostat: calibrating and fine-tuning the tonus within the postural muscles of the body. This is effectively monitored using Pressure Plate Analysis. Bracers consistently have higher media pressure readings and lower foot surface area readings. Releasers consistently have lower media pressure readings and higher foot surface area readings. These readings become more normalized when insole therapy is effective, more skewed when insole therapy is ineffective. For example, excessive tactile stimulation in a braced patient will frequently increase both the surface area readings (normalized) and media pressure readings (skewed).

References

1. Rothbart BA. Medial Column Foot Systems: An Innovative Tool for Improving Posture. Journal of Bodywork and Movement Therapies 2002(A)1:37-46
2. Johnson K, Cross N. Common Compensatory Pattern and Its Relation to Lumbar Facet Angles. Journal American Osteopathic Association 1990; 90:942.
3. Liley P. Postural Analysis {2 hour panel presentation}. Head Guidance and Ground Support. Annual Conference, American Academy of Pain Management, Washington Dc, 1996.

4. Rothbart BA, McCombs A, and Riniker L. BioImplosion. The Treatment of Chronic Pain Syndrome. Annual Conference, American Academy of Pain Management, Dallas, 1992.
5. Rothbart BA, Esterbrook L. Excessive Pronation: A Major Biomechanical Determinant in the Development of Chondromalacia and Pelvic Lists. Journal Manipulative Physiologic Therapeutics 1988;11(5): 373-379.
6. Rothbart BA, Yerratt M. An Innovative Mechanical Approach to Treating Chronic Knee Pain: A BioImplosion Model. American Journal of Pain Management 1994; 4(3): 123-128.
7. Rothbart BA, Liley P, Hansen K, Yerratt K. Resolving Chronic Low Back Pain. The Foot Connection. American Journal of Pain Management 1995; 5(3): 84-49
8. Sewell RS. A Study of the Astragalus (Talus). Part IV. Journal of Anatomy and Physiology 1906;40:152
9. Straus WL. Growth of the human foot and its evolutionary significance. Contributions in Embryology 1927;19:95 Vols 21, 32, 34, Washington DC. Carnegie Institution of Washington.
10. McPoil T et.al. Anatomical characteristics of the talus in relation to forefoot deformities. Journal American Podiatric Medical Association 1987; 77:77-81.
11. Sarrafian SK. Anatomy of the Foot and Ankle. 1983 JB Lippincott, Philadelphia
12. ibid
13. Straus WL. Growth of the human foot and its evolutionary significance. Contributions in Embryology 1927;19:95 Vols 21, 32, 34, Washington DC. Carnegie Institution of Washington.
14. Olivier G. Formation du Squelette des Members. 1962;145-189. Paris, Vigot, Freres.
15. Rothbart BA. Medial Column Foot Systems: An innovative tool for improving posture. {Foot}Embryology. Journal Bodywork and Movement Therapy 2002(A);1:39-41.
16. Lisowski FP. Angular growth changes and comparisons in the primate talus. Folia Primatologia. 1967; 7:81-97.
17. Yamazake K, Ishida H. A biomechanical study of vertical climbing and bipedal walking in gibbons. Journal of Human Evolution, 1984;13:563-571.
18. Martin RD. Primate Origins and Evolution. A Phylogenetic Reconstruction. 1990, Chapman & Hall, London.
19. Rothbart BA. Postural Kinetics. Faculty Member, Annual Conference of the American Academy of Pain Management, Dallas 1995
20. Caffey JP. Pediatric X-Ray Diagnosis. 1972;Vol.2:884. 6th Edition, Yearbook Medical Publishers, Chicago.
21. Lang J, et.al. Praktische Anatomic Erster Band Vierter Teil – Bein und Statik. 1972:31, Berlin, Springer Verlag.
22. Hoerr LN, et.al. Radiographic Atlas of Skeletal Development of the Foot and Ankle – A Standard Reference. 1962 Charles C Thomas, Springfield.
23. Blais MM, Green WT, et.al. Lengths of the growing foot. Journal Bone Joint Surgery. 1956;38(A):998
24. Inman VT. The Joints of the Ankle. Biomechanics of the Subtalar Joint. 1976:Chapter (11):57-66. Williams and Wilkins, Baltimore.
25. Rothbart BA. Etiology of Foot Hyperpronation. An Embryological Perspective. F Painter ed. http.//www.chiro.org/LINKS/articles.shtml
26. Ball K and Afheldt M. Evolution of foot orthotics. Part 2 – Research reshapes longstanding theory. Journal Manipulative and Physiological Therapeutics. 2002;25:116-124
27. Fusco MA. Atlas of Plantar Posturology. 2000 Scuderi Editrice, Italy.
28. Gagey PM and Gentaz R. Chapter 16: Rehabilitation of the Spine. 1996 Williams and Wilkins.
29. MidiCapteurs Podolab 2000 Pressure Plate Analysis. http.//www.midicapteurs.fr 18, Ave. Charles de Gaulle, Les Espaces de Balma, Balma France, 31138.
30. Rothbart BA. Etiology of Foot Hyperpronation. An Embryological Perspective. F Painter ed. http.//www.Chiro.org/LINKS, 2002