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Is it still current to talk about first ray hypermobility?

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Summary. Since the time of D. Morton in clinical evaluation we talked about the concept of hypermobility as a cause of diseases such as hallux valgus. To date, this concept has been deepened in order to better understand the pathological mechanisms that create deformity, in order to identify the most appropriate prevention and correction procedures. Physics introduced the concept of stiffness, a property that also belongs to the podalic structures. Changing the terminology is difficult, but the knowledge of biomechanics requires the elimination of the term hypermobility because it resultsinconsistent with the physics applied to the foot, in favor of the terms stiffness and compliance. These clarifications make it possible to us to deepen even more specific and timely therapeutic choices, thus reducing the risk of iatrogenic complications which follows interventions on the first ray. (www.actabiomedica.it)

Key words: first ray, hypermobility, stiffness

In the clinical setting since D.Morton, 1935, we talked about the concept of hypermobility as a cause of hallux valgus. To date this concept has been investigated to better understand the pathomechanic that produced deformity, and to plan the best preventive and corrective procedures. Phisics introduced the concept of stiffness, a property that also belongs to the structures of the foot. It is difficult change the terminology, but the knowledge of the biomechanics of the foot requires the removal of the term hypermobility because it's inconsistent with phisics applied to the foot, in favour of the terms stiffness and compliance.

During deambulation the forefoot must be enough flexible in order to absorb the ground reaction forces but also stiff enough to support weightbearing and to shift the center of gravity forward during gait. The first ray consists of the first metatarsal and medial cuneiform as osseus components, and it's considered the most important ray in the biomechanics of the foot. Motion of first ray has long been recognized as an important component in the overall function of the foot during gait, indeed there are more references about the pathologies of first ray. One of the most common condition is the increased mobility in dorsiflexion of the first ray during the ankle rocker, defined as the condition of hypermobility, from Greek, "hyper", usually implying excess and "mobile" meaning " capable of moving or being moved readily" (1). In 1935, Dundely Morton was the first to describe the condition of hypermobility of the first ray as "…the plantar ligaments of the first metatarsal segment in these feet were lax when the other ligaments had become tense under body weight; hence the first metatrsal still retained a margin of dorsal extension and therefore was ineffective as a weightbearing structure."(2) Inducing a overweight to the lateral metatarsal (Fig 1-2). Other authors have defined in different way the condition of first ray hypermobility. In 1977, M. Root et al (3-4) defined hypermobility as "a state of abnormal first ray instability that occurs while the forefoot is bearing weight.: while forefoot is bearing weight during forefoot rocker and it's the result to attempt the first metatarsal head while hindfoot pronated".

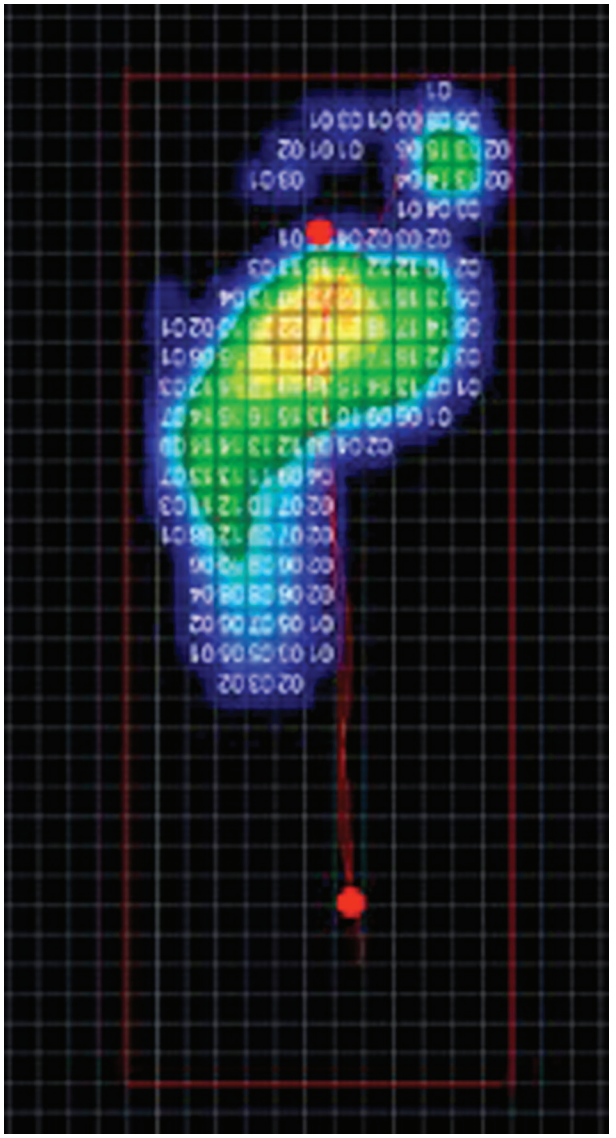

Figure 1. This image show the overload in central metatarsal head produced by recrewased indorsiflexion stiffness

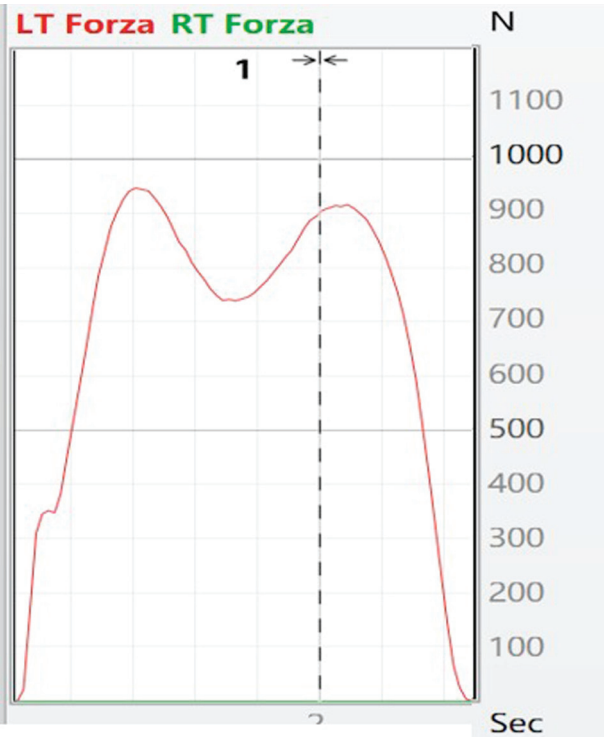

Figure 2. Butterfly of one step

Root et al attributed to excessive of pronation of subtalar joint and to the resulting grades of eversion of rearfoot, the cause of first ray hypermobility. Nevertheless this condition is one of the most frequent cause of pathomechanic of the first ray and conseguent first metatharsophalangeal pathomechanic because it produces, according to Root et al (3), inversion and dorsiflexion of the first ray, which are responsible of the subluxation of the first methatarsophalangeal joint, (hallux limitus and halux abductus valgus) and the lateral rays and metatarsophalangeal joints. The first clinical evaluation of hypermobility was described by Root et al. (3-5). It consisted in placing subtalar joint in its neutral position (which STJ is neither pronated nor supinated with midtarsal joint fully loaded along longitudinal axis) while first hand stabilizes the second through fifth metatrsal heads and the on the other hand stabilizes the first metatarsal head. In this position, the first metatarsal head is brought into full dorsiflexion and full plantarflexion; the range of motion in both directions is determined by comparing the position of the examiners fingernails dorsally and thumb nails plantarly. McInnes and Bouché (6) used Root et al's test to define the position of the first ray:1) parallel: the first and the second metatarsal heads have a "level" starting position and equal dorsiflexory and plantarflexory excursion; 2) elevated: the first metatarsal's starting position is higher than the second and it is able to dorsiflex to or above the dorsal aspect of the second metatarsal, 3) plantarflexed: the first metatarsal's starting position is lower than the second and is unable to dorsiflex past the plantar aspect of the second metatatrsal. Roukis et al (6) preferred tecnique to assess first ray mobility consist in placing the ankle

and subtalr joint in their neutral position, while stabilizing with one hand the second through fifth metatarsal heads as the other hand stabilizes the first metatarsal head. The hallux is fully dorsiflexed at the first metatarsophalangeal joint and a dorsally and plantarly directed force is applied to the first metatarsal head. The resultant dorsal and plantar first ray motion as determined by this so-called "Dynamic Hicks test" is then compared with the available first ray motion, as determined through root et al's first ray clinical mobility test.

This clinical evaluation of hypermobility in open kinetic chain is not reliable, because the hypermobility is a condition that is verificated during stance and gait. Today the scientific research, as reported by K.A. Kirby and T. Roukis (1), has introduced the new term "stiffness to descrie the ability of a structure to resist changes in shape; stiffness is defined as the amount of force required to produce a given amount of deformation or the amount of stress within a material required to produce a given amount of strain in that material, generally in Newtons per meter (N/m); Compliance wich is the inverse of stiffness is defined as the amount of deformation produced by a given amount of force and is generally described in units of meters per Newton (m/N). Using the term hypermobility during stance phase of the gait to describe the force that produces movement is misleading and imprecise." Thus it is better to define the hypermobility condition as a decrease in first ray dorsiflxion stiffness. Therefore dorsiflexion stiffness is defined as amount of force on the plantar first metatarsal head required to produce an amount of movement in dorsiflexion of the first ray. in presence of a decrease stiffness in first ray dorsiflexion, the first metatarsal head will be unable to accept its normal share of GRF in forefoot an so it will produce an increased dorsiflexion movement of the first ray and an overload on second metatarsal head. Every single ray has its own stiffness, and the biomechanic of the forefoot depends on the resultant of the sum of single rays stiffness. This property is influenced by all biomechanics of the foot, from the moment of pronation of Subtalar and midtarsal joint, and even from internal forces of muscles and ligaments; just think about the action of peroneus longus as stabilizer during platarflexion of the first ray or about the action of hallux longus flexor or hallux brevis flexor, or hallux abductur which produce a moment of plantarflexion of the first metatarsal. In 1999, Benno Nigg (7) described the changes in amplitutede of GRF on the first metatarsal head during gait produced by variations of the dorsiflexion stiffness of the first ray; these forces indeed produce a displacement of CoP [CoP is defined as the point location of the center of all the forces acting on the plantar foot (7)] toward the plantar zone of the foot. Then Eric Fuller (8) pointed out that when GRF increase on the first metatrsal head, a medial displacement of the CoP toward first metatarsal head occur, whereas instead if GRF decrease on the first metatrsal head, CoP displacement occurs lateral to the first metatrsal head. This produces an abnormal biomechanic of forefoot leading to a further pronated or supinated moment of the foot. Then, summing up, the decreased dorsiflexion stiffness of the first ray shifts Cop laterally respect to the first metatarsal head and produced an increased of pronated moment of subtalar joint or reduced supinator moment of subtalar joint, according to the axis of the joint. In case of increased dorsiflexion stiffness of the first ray, CoP displacements medially to the first metatarsal head, thus increasing the supinator moment of SBJ or decreasing the pronator moment, always according to the axis of the joint.

Conclusions

The concept of hypermobility has been ingrained in our professional terminology since many years, but the technology and the increasingly detailed study of the forces acting on the foot during stance, gait or sport activities , led us to a more accurate definition of phisiological and patological conditions of the foot. These knowledges allow us to deepen the therapeutic choises, which are getting more and more specific and timely, and to reduce the risk of iatrogenic complications which follow interventions on the first ray.

References

1. Kirby KA, Roukis TS. Precise naming aids dorsiflexion stiffness diagnosis. Bioemchanics 2005; July: 55-63.

2. Kirby KA. Biomechanics of the Gastrocnemius-Soleus Complex, Foot and Lower Extremity Biomechanics IV: Precision Intricast Newsletters, 2009-2013, 43-44.
3. Root ML, Orien WP, Weed JH. Normal and abnormal function of the foot. Ed. Piccin, 2001, vol 2.
4. Kirby KA. Foot and Lower Extremity Biomechanics III: Precision Intricast Newsletters, 2002-2008, 85-104.
5. Roukis TS. Position of the first ray *and* motion of the first metatarsophalangeal joint. JAPMA 1996 Nov; 86(11): 538-46.
6. Roukis TS., Landsman AS, Hypermobility of the first ray: a critical review of the literature. Foot & Ankle Surgery 2003 Nov; 42(6): 377-390.
7. Nigg BM, Herzog W. Biomechanics of the muscolo-skeletal system, 2^edition, Wiley
8. Fuller EA. Center of pressure and its theoretical relationship to foot pathology. JAPMA 1999; 89(6): 278-291.

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