PLANTAR FASCIITIS: AN UPDATE ON CLINICAL AND BIOMECHANICAL FEATURES

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Plantar fasciitis is an inflammatory condition characterized by pain in the medial. central and lateral compartments of the plantar fascia accompanied by stiffness. It is common overuse injury among runners and athletes who practise in jumping sports. The plantar fascia, which is responsible for mantaining the integrity of the longitudinal arch, becomes imtated, inflamed or tom by repetitive stresses upon it.

Anatomical considerations of the plantar fascia

The plantar fascia is a dense, fibrous band of connective tissue on the plantar surface of the foot. The plantar fascia is attached proximally at the medial tubercle of the calcaneus and runs forward for the length of the foot to its distal attachments in the ball of the foot, where it then splits into five divisions which are inserted into the phalanges of the toes.

The fascia is made up of a central, a lateral and a medial sector. It emerges from the calcaneal tuberosity posteromedially and finishes as an integral part of the achilleo-calcaneo-plantar functional system, to which it is linked by numerous tendineous fibres.

The central sector is triangular in form with a posterior apex and anterior base. At the level of the third medium metatarsal it divides into five strips; the three middle toes and the other two run towards the first and fifth toes. Although not directly attached to them, it plays a minor role in the formation of the fasciculi trasversi ligament.

Running along the top of the central component, bordered laterally by the lateral and medial intermuscular septi, are the brevis digitorum muscle, the tendon of the flexor longus digitorum and the fourth lumbricales muscles, musculus quadratus plantae aspect of tibialis posterior tendon.

The medial sector of the fascia is thin posteriorly and wide anteriorly and includes the abductor muscle, the flexor brevis of the big toe and the tendon of the flexor longus allux. (In this way the medial plantar compartment is identified).

The lateral sector of the fascia is a structure of variable anatomical shape. It begins at the lateral margin of the medial-calcaneal-tuberculus, in close relation to the abductor muscle of the fifth toe, and extends towards the cuboid bone, dividing into two bands: the lateral one is attached at the level of the fourth or sometimes third metatarsal phalangeal joint. Within this component run the abductor, the flexor brevis of the toes and the opponent muscle of the fifth toe. (In this way the lateral plantar compartment is identified).

During the stance phase on the ground, the plantar fascia reduces the lowering of the longitudinal arc and improves the thrust efficiency from 25% to 50% of the stance phase. The fascia undergo stretching in relation to the mechanics and podalic spatiality and in this period solicitations occur around the calcaneal attachment of the fascia.

Causes of Plantar Fasciitis

Plantar fasciitis is an overuse injury. Overuse injury occurs when a structure or system is exposed to repetitive forces beyond the abilities of that specific structure or system to withstand or adapt to such a force. Plantar fasciitis has been classified as an

overuse injury resulting from overload to the plantar fascia at its insertion into the calcaneus. This overload is thought to cause microtrauma and inflamation in the fascia at or near the fascia-bone interface.

Various biomechanical, anatomical or environmental explanations have been proposed to explain the overload condition.

Aetiological factors could be divided into five categories: training errors, strength and flexibility abnormalities, running shoes, training surfaces and biomechanical alterations.

Training errors include high intensity training without adequate recovery time, a sudden increase in training intensity, a single severe training or competitive session and a sudden increase in hill running. The athletes need to allow the supporting structures of the body, and expecially the lower leg. sufficient time to adapt to the increased load. The body does have the capacity to adapt to imposed workload, but the load intensity. and resulting adaptation, must be gradual rather than sudden, otherwise the tissues are broken down faster than their ability to recover (Watson,1988).

Strength and flexibility abnormalities create an alteration in normal biomechanics of the foot that decreases the efficiency of force absorption and production. Saggini et al. (1991) and Kobler et al. have shown that a very high incidence of plantar flexor muscle strength deficits during concentric and eccentric isokinetic contraction and dorsiflexion range of motion deficits is associated with plantar fasciitis. Solomonow et al have shown that strong, balanced muscles are able to decrease joint loads. In our experience, the plantar fascia may be stressed particularly by the peronei, which are still weak after incomplete rehabilitation following ankle sprains, causing a reduction of support by the arch.

Biomechanical abnormalities should be considered contributing factors to plantar fasciitis because of poor absorption of ground reaction forces by the foot. Pes planus or rigid cavus foot, tight Achilles tendon and excessive subtalar pronation may increase stress on the plantar fascia.

Excessive pronation results in the plantar fascia abnormally stretching during the midstance phase of nznning (Adelaar,1986). The cavus foot has a high arch which is rigid and unable to assist in the absorption of ground reaction forces created during running and increasing the tension of the plantar fascia at its point of insertion (Taunton et al.,1982).

Pes planus may be caused when the ligaments of the foot and arch become weak, resulting in the stress on the arch being tranfered to the plantar fascia (Micheli,1986). Shoes with a loose, poorly fitted heel counter may also allow subtalar pronation to occur. A loose hill counter lets the calcaneal fat pad spead at heel strike, permitting increased transmission of impact to the calcaneus and plantar fascia (Brody,1986).

The purpose of this work is to compare 30 runners affected by plantar fasciitis, before and after the resolution of the pathology with follow up of three months, to a normal control group to point out:

a) the different areas of pain and the referred pain;

b) the isokinetic muscular performance of the plantar flexor muscle, using a Cybex 6000 isokinetic dynamometer;

c) the data of the ground-reaction by means of a Bertec force plateform.

MATERIALS AND METHODS

Thirty male subjects (m. age 26, max 38, min 18), professional runners, affected by plantar fasciitis are tested with:

-aesthesiological method using a Lace Instruments to define the cheracteristics and the site of the pain and the referred pain;

-isokinetic method, using a dynamometer isokinetic Cybex 6000, performed concentrically and eccentrically at 30 deglsec. 60 deg/sec, 90 deg/sec and 180 deglsec with the subject prone and knee extended;

-gait analysis, using a Bertec force plateform at defined pace (6 km/h). The data have been analyzed about the trend of Fz, Fy, Fx and the morphology of the sagittal vectograms.

Before the instrumental tests, a clinical and physical evaluation has been performed also to examine alignment of body parts, and the anatomical abnormalities.

RESULTS

As regard the foot structural abnormalities, the physical examination has showed:

- 22 subjects with a rearfoot valgus and forefoot valgus;
- 4 subjects with a rearfoot valgus;
- 4 subjects with a rearfoot varus and 2 of those with associated a first metatarsal plantarflexed.

All subjects present a deficit of the ankle range of motion compared to normative standards, to control group and the uninvolved foot.

The clinical evaluation has demonstrated a unilateral plantar fasciitis in 30 subjects.

The heel pain is described as that of a sharp pain diffused on the plantar surface and arch pain as a burning sensation.

This painful condition is worse when the area is cold or contracted, such as upon getting up in the morning, or getting up after exercise.

The passive dorsiflexion increases the pain along the medium plantar fascia and the flexion or extension of the great toe is often limited.

The flexibility was reduced in 5 subjects.

In our work on 30 subjectes affected with plantar fasciitis, the study of characteristics of the pain via aesthesiological methods has shown:

-in 16 cases (group A) the pain was localized at the calcaneum attachment with clear reduction of the dorsiflexion capacity of the foot compared with the unaffected side revealed both by pressure and by transverse palpation and the area of referred pain was detected after mechanical stimulation of the algogenic focus in the median part of the central aponeurosis about 2.5 cm proximodistally from the area of pain. The pain always appeared gradually, with onset and high intensity at the moment of pressure on the ground, expecially during the first phase of the walk. The pattern was first intermittent and then continuous both at rest and while walking;

-in 10 cases (group B) the pain was localized in the middle third of the medial part of the plantar fascia, at the level of the tendinous structure of the long flexor of the big toe, with a taut palpable band and clear reduction of the dorsiflection motion of the forefoot compared with the controlateral one. The pain could be reproduced both by pressure and by transverse palpation and the target area was detected with mechanical stimulation around the algogenic focus localized disto-proximally in the middle third. The pain had begun when walking and was of moderate degree, subsequently reaching high intensity after about 30 minutes movement. The pattern was continuous in time, the pain first present only at movement and then also at rest;

-in 4 cases (group C) the pain wadlocalized in the middle third of the lateral part of the plantar fascia, at the level of the tendinous structure of the abductor of the fifth toe. There was a clear reduction of the dorsi flection motion of the forefoot compared with the unaffected controlateral one. The pain could be reproduced both by pressure and the target area was found around the algogenic focus after mechanical stimulation localized around the middle third disto-proximally to the peroneus muscle attachment at the base of the fifth metatarsal bone. The characteristics of the pain were in every way similar to these of group B.

The esthesiological evaluation in basal conditions in the three groups showed cutaneous and muscular pain thresholds in the algogenic focus lower than those of the unaffected controlateral side.

After 3 months from the resolution of the plantar fasciitis the aesthesiological evaluation in basal conditions in the three groups showed a normalized cutaneous and muscular pain thresholds in the algogenic focus site.

Our isokinetic tests compared to the uninvolved foot showed a complete incidence of plantar flexor muscle strenght deficits during the eccentric contraction at the explorated velocity and during the concentric contraction at 30 deglsec, 60 deg/sec and 90 deglsec; as regards 180 deglsec only 60% of the subjects showed a weakness.

The tests at 3 months after the clinical resolution showed a significantly increase (p. 001) of plantar flexor muscle at 30 deg/sec, 60 deglsec, 90 deglsec and 180 deglsec concentrically and at 30 deglsec, 60 deglsec and 90 deglsec eccentrically.

At 180 deglsec eccentrically was present a deficit of 25% compared to uninvolved foot.

Our study on the ground-reaction at defined cadence has shown an alteration of these parameters during the stance phase:

a) high vertical force on impact;
b) shear force reduced;
c) lower vertical force on termical stance;
d) marked inversion of the normal vectograms curve.

The gait re-examination of the treated subjects after 3 months of clinical resolution has shown that only two parameters were remained:

a) high vertical force (Fz) on impact;
b) marked inversion of the normal vectograms curve.

CONCLUSIONS

According to the literature, the etiology of the plantar fasciitis is multifactorial. The analysis of our data shows:

1) the parameters of the ground reaction represent abnormal biomechanical characteristics, intrinsic to the body's motion, which are able to promote the oneset of the pathology;

2) the evidence of the rearfoot valgus, often associated with the forefoot valgus, is a foot structural abnormality which is able to favour the development of the overuse of the plantar fascia;

3) the aesthesiological evaluation has permitted to discover three different algogenic focus and referred pain which are able to determine the pain of the plantar fascia;

4) the isokinetic data show a reduced capability of the plantar flexor muscle to provide a concentric and eccentric performance in relation to the presence of the algogenic focus.

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FIGURES

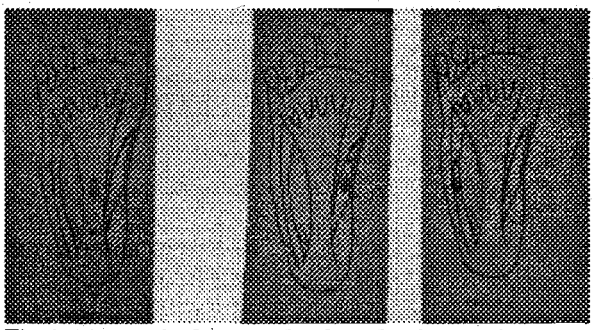

Fig.1 Algogenic focus and referred pain area in central plantar fasciitis.
Fig.2 Algogenic focus and referred pain area in medial plantar fasciitis.
Fig.3 Algogenic focus and referred pain area in lateral plantar fasciitis.

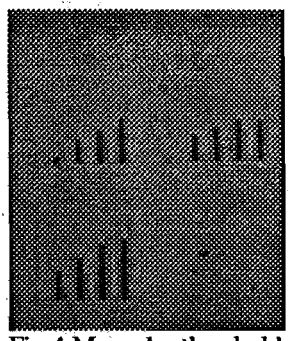

Fig.4 Muscular thresholds with electrical stimulation in groups A, B, C during the pathology and after 3 months after the clinical resolution.

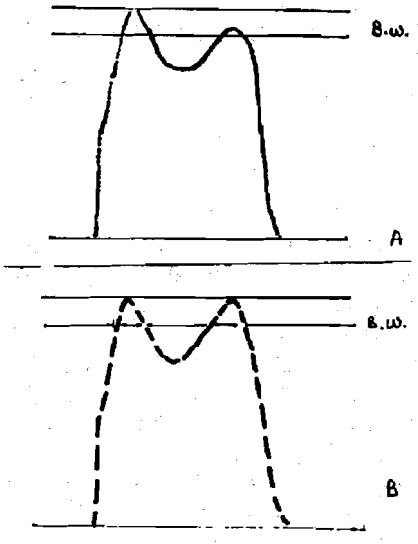

Fig.5 The trend of Fz during impact and terminal stance at the pathology (A)and at 3 months after the clinical resolution (B)

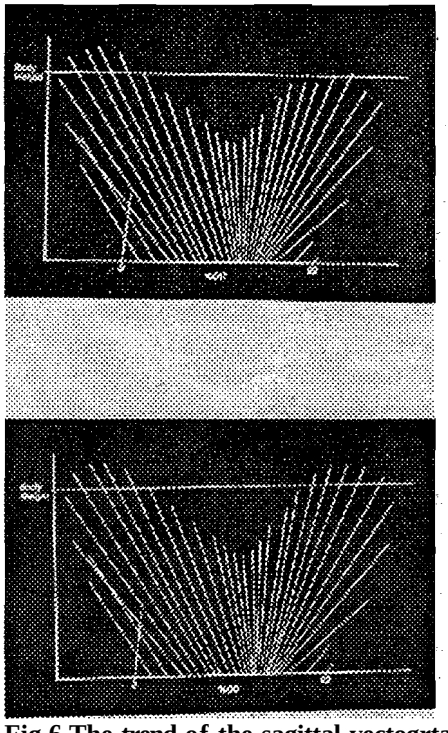

Fig.6 The trend of the sagittal vectogrtam at the pathology (A) and at 3 months after the clinical resolution (B)