Research Article

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Plantar Fascia Properties in Physical Medicine and Rehabilitation of the Lower Limb

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Abstract

It has been accepted plantar fascia thickness is a biomechanical variable. (Wearing et al., 2006, Garcia et al., 2008) Plantar fascia has long been connected to the kinematics and kinetics qualities of the ankle and foot. (Gefen, 2002) The objective of this research is better understanding the specific properties of the plantar fascia in living individuals.

Method

1. *Analyze the previous studies and methods about plantar fascia properties.*
2. *To find a method to study mechanical properties of the plantar fascia in living individual in static and locomotion.*
3. *Plan of investigation was designed to recognize each location of the plantar fascia along its length on both feet.*
4. *Scanning ultrasound images.*
5. *Pressure marker, E-med and motion analyzer.*

The outcome of this research can be resulted in arranging a physical medicine / rehabilitation schedule of the lower limb in treatment, prevention and rehabilitation according to the properties of the body of living individual, as close as possible. Additionally, rehabilitation schedule can be more effective and secondary problems can be decreased, also.

Keywords: Plantar fascia thickness; Plan of investigation; Ultrasound; Motion analyzer; vertical load.

Introduction

Plantar fascia has long been connected to the kinematics and kinetics qualities of the ankle and foot. (Gefen, 2002) The functional role of the plantar fascia is dependent on its mechanical properties. (Wearing et al., 2006) Thickness of the plantar fascia is different along the length of the plantar fascia. It is modified under loading, also. (Garcia et al., 2008) Plantar fascia is composed of compacted longitudinal, transverse and oblique collagen fibers and elongates in loading and stores energy. (Bartold, 2004) Consequences concerning the proper- ties of the plantar fascia and its effect on the structure and function of the foot and ankle have been attained through cadaveric and modeling studies. (Wearing et al., 2006), (Erdemir et al., 2004), (Gefen, 2002), (Cheung et al., 2006), (Hammer, 2008).

On one hand, thickness of the plantar fascia is parameter to identify the location along the length of the plantar fascia. (Huerta & García, 2007) On the other hand, thickness of the plantar fascia is modified under loading. (Garcia et al., 2008) On one hand, plantar fascia transmits force be- tween the hind foot and fore foot. (Erdemir et al., 2004) On the other hand, plantar fasciitis is common at the calcaneal attachment in middle-aged individuals. (Puttaswamaiah et al., 2007) On one hand, plantar fascia like ligaments has viscoelastic properties in the cadaveric foot. On the other hand, there are histological differences between plantar fascia and ligaments. (Wearing et al., 2006) On one hand, plantar fascia is medial longitudinal arch stabilizer. On the other hand, plantar fascia has a limited ability to elongate (Bartold, 2004).

On one hand, the direction of the plantar fascia is effective to maintain the medial longitudinal arch throughout the gait. (Bolgla & Malone, 2004) On the other hand, plantar fascia is divided in different planes and is attached to the various tissues. (Aquino & Payne, 1999) On one hand, plantar fascia is static and dynamic stabilizer of the medial longitudinal arch. (Puttaswamaiah et al., 2007) On the other hand, most cadaveric studies have focused on the biomechanical consequences of complete plantar fascia releasing (Cheung et al., 2004).

That's why it has been decided specific properties of the plantar fascia are studied in living individual in static and locomotion.

Method

Analyze the previous studies and methods about plantar fascia properties.

The aim of reviewing previous studies is better comprehension about the plantar fascia char- acteristics, structure, function and unknown key facts (La Porta et al., 2005, Wearing et al., 2006), (Grinnell, 2007), (Langevin & Huijing, 2009), (Hammer, 2008), (Caravaggi et al., 2010), (McNally & Shetty, 2010), (Dugan & Bhat, 2005), (Wright & Rennels, 1964).

Study mechanical properties of the plantar fascia in living individual in static and locomotion: (Wearing et al., 2006; Garcia et al., 2008), (Bolgla, 2004).

Plan of investigation is to identify the location of the plantar fascia along its length in un- loading and before modification in both feet. The plan of investigation is designed depending on 6 non weight bearing landmarks. Handheld calipers are used to calculate the measurements of the foot (Butler et al., 2008), (Glasoe et al., 2002) In this plan, OO' is the mid line of the plantar aspect of the foot.

To register specific location of the plantar fascia, ultrasound images in sagittal and frontal planes are scanned. (Akfirat & Gunes, 2003), (Gibbon & Long, 1999, Vohra et al., 2002) Plantar aspect of the foot is upward; Ultrasound scanning can be done in prone position with flexed knees and ankles. (Glasoe et al., 2002), (Huerta & García, 2007) Thickness of the plantar fascia is evaluated via "Image J" software with the resolution of tenth of a millimeter. The oo' line is registered on the mid line of the monitor in ultrasound. The thickness is measured from both sides of the mid line every 5mm.

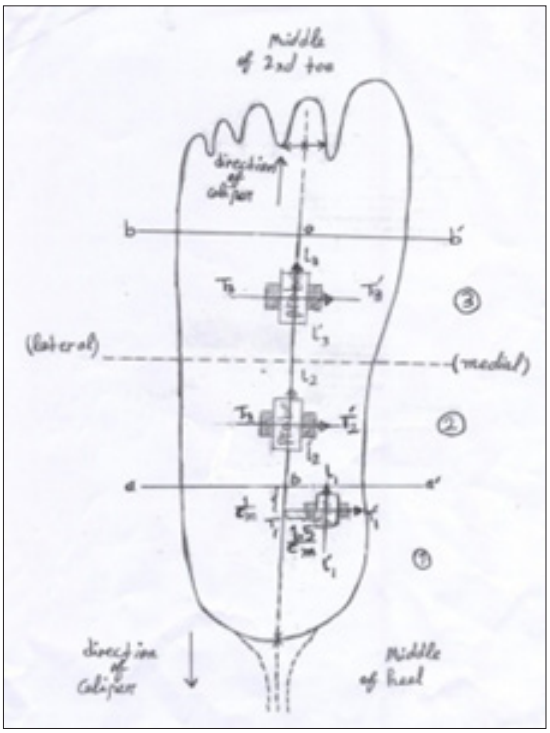

Figure 1: Plan of investigation

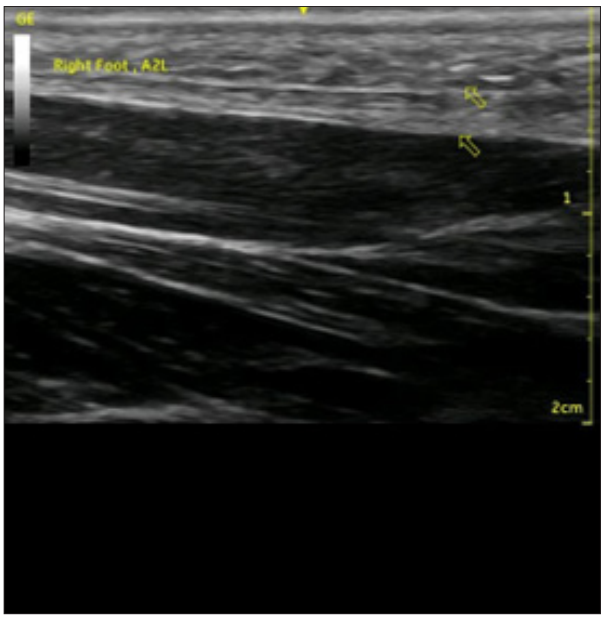

Figure 2: Ultrasound image, Right foot, Area2, Longitudinal

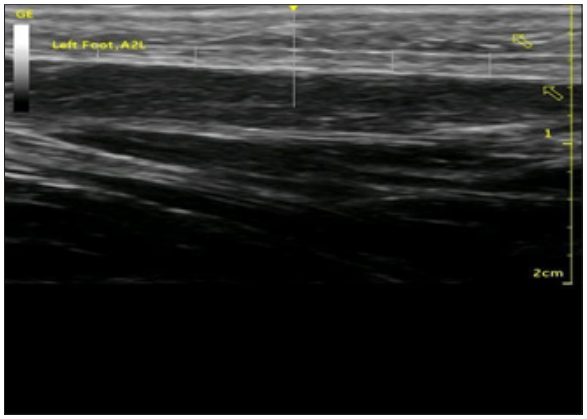

Figure 3: Ultrasound image, left foot, Area2, Longitudinal

Reliability and validity of the plan: For reliability of the plan two orthoptists with different levels of experience take blinded measurements and depict the plan. Landmarks are transferred on transparent paper in short sitting position. For validity of the plan, the distance be- tween landmarks is compared with distance in x-ray in short sitting position (Williams & McClay, 2000).

Reliability and validity of quantifying the thickness of the plantar fascia: For reliability, the evaluation is repeated seven times. For validity, the evaluation is done from left to right and from right to left, every 5mm. (The mean of the plantar fascia thickness in each location is calculated after seven times evaluation then Standard Deviation (SD) of that area is computed.)

Pressure marker, E-med (Foot Pressure Scanner), Motion analyzer.

Pressure markers are put in identified location which its thickness is close to the mean of the plantar fascia thickness in each area of the plantar aspect of the foot.

Figure 4: E-med and Motion analyzer

Figure 5: Pressure marker

The aim is identifying how much pressure is applied on identified thickness of the plantar fascia in static and locomotion (Bolgla & Malone, 2004), (Keijsers et al., 2009; Mac Williams et al., 2003).

Reliability and validity of experimental model: For reliability, each test is repeated ten times. For validity, test is taken with similar confirmed models (MacWilliams et al., 2003; JenKyn & Nicol, 2007).

Reliability and validity of the identified location of the plantar fascia on Emed: For reliability, the length and the width of the location is measured ten times. For validity, ±SD shows the displacement of the pressure marker.

Results

Table 1: The quantity of the applied load on the plantar fascia in erect posture

Area (Right foot)	Thickness of the identified Location of the plantar fascia (Ultrasound)		Identified location of the plantar fascia on (E med)		The quantity of the applied pressure Mean (KPa) ± SD	The % of the body weight (70 Kg) applied in identified location of the plantar fascia
	Longitudinal Mean(mm) ± SD	Transverse Mean(mm) ± SD	Length Mean(mm) ± SD	Width Mean(mm) ± SD		
1	3.8 ± 0.4	2.3 ± 1.0	74 ± 1.6	26 ± 2.8	46.6 ± 13.1	0.6% ± 0.18%
2	1.2 ± 0.7	1.1 ± 0.6	101.6 ± 1.7	48.3 ± 3.6	51.6 ± 6.2	0.7% ± 0.09%
3	1.3 ± 0.3	1.4 ± 0.2	151.3 ± 2.6	41 ± 2.9	43.3 ± 4.7	0.6% ± 0.67%

Table 2: The quantity of the applied load on the plantar fascia in mid stance:

Area (Right foot)	Thickness of the identified Location of the plantar fascia (Ultrasound)		Identified location of the plantar fascia on (E med)		The quantity of the applied pressure Mean (KPa) ± SD	The % of the body weight (70 Kg) applied in identified location of the plantar fascia
	Longitudinal Mean (mm) ± SD	Transverse Mean (mm) ± SD	Length Mean(mm) ± SD	Width Mean(mm) ± SD		
1	3.8 ± 0.4	2.3 ± 1.0	85.6 ± 3.9	22.2 ± 4.7	60.8 ± 17.6	0.8% ± 0.25%
2	1.2 ± 0.7	1.1 ± 0.6	114.6 ± 4.0	46.4 ± 4.1	71.6 ± 3.7	1.0% ± 0.052%
3	1.3 ± 0.3	1.4 ± 0.2	166.4 ± 4.7	46.4 ± 5.2	59.1 ± 20.1	0.8% ± 0.28%

Table 3: The quantity of the applied load on the plantar fascia (forefoot) in double support of stance phase

Area (Right foot)	Thickness of the identified Location of the plantar fascia (Ultrasound)		Identified location of the plantar fascia on (E med)		The quantity of the Applied Pressure Mean (KPa) ± SD	The % of the body weight (70 Kg) applied in identified location of the plantar fascia
	Longitudinal Mean (mm) ± SD	Transverse Mean (mm) ± SD	Length Mean (mm) ± SD	Width Mean (mm) ± SD		
1	1.3 ± 0.3	1.4 ± 0.2	166.4 ±4.7	46.4 ± 5.2	78.3 ±19.5	1.1% ± 0.27%

Force (N) = Pressure (Pa). Area (m^2)1 (Kg) = 9.8 (N)(9.8 ~ 10)

Importance / Novelty of Research

To evaluate different thicknesses of the plantar fascia along its length in unloading in living individual.

To evaluate equivalent locations of the plantar fascia thickness in opposite foot.

Thickness of the plantar fascia can be evaluated in each location in two planes (sagittal and frontal).

To quantify the amount of the vertical load (body weight) applied on the identified location of the plantar fascia in living individual.

The angle of lower limb joints (ankle, knee, hip) and medial longitudinal arch and the amount of the applied vertical load (body weight) can be evaluated simultaneously, in static and locomotion, also.

Conclusion

To find a scale of the body characteristics of living individual can be achievable and effective in prevention, treatment and rehabilitation. Without this scale, prevention can be unsure, treatment schedule is done step by step and therapist should follow trial process in rehabilitation.

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