Pressure and Traction technique improve Postural Control more than tactile stimulation in foot plantar fascia. A randomized single-blind trial.

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Abstract

Background. The fascial system has a solid and a liquid component. Inside the solid component we find a large number of mechanoreceptors. Myofascial treatment is effective in reducing myofascial pain, increasing range of motion, improving functional disability and pressure pain threshold. However, no research examining the effect of fascial treatment on footprint and bipodal static balance was found.

Objetive. The aim of this clinical trial is to check the effects of manual pressure and traction technique on balance and plantar footprint variables. The protocol registration number is ID: NCT03997955

Methods. Forty healthy subjects (28 females and 12 males) were recruited for a simple blind study. They had 39.42±10.41 years old, 167.65±8.39 cm height, and 67.72±9.11 kg weight. Participants were randomized into two groups. Experimental group performed a bilateral plantar fascia manual pressure and traction technique. Control group performed a tactile stimulation. The duration (5 minutes), position, and therapist were the same for both treatments. We measured stabilometry variables and static footprint. The footprint variables were divided in bilateral rear foot, bilateral midfoot, bilateral fore foot.

Results. Significant differences were found in stabilometry variables. There was an improvement in experimental group at X displacement with eyes open ($p=0.014$) and Surface eyes closed ($p=0.046$) variables.

Conclusions. After technique the experimental group improved the stabilometry variables, specifically, surface with eyes closed and x displacement with eyes open. The static footprint variables have not shown differences after the technique compared to the control group.

Keywords: myofascial, plantar fascia; fascia; postural balance; stabilometry; platform.

Abbreviations:

SD (standard deviation)

Mm (millimeters)

EC (eyes closed)

EO (eyes open)

a-p (anterioposterior)

1. Introduction.

Fascia is a connective tissue organized in a three-dimensional network, that surrounds, supports, suspends, protects and connects muscular, skeletal and visceral components of the body(1). The fascial system has a solid and a liquid component, acting in a perfect symbiotic synchrony thanks to each cell communicates with the other cells (2). Inside the solid component we find a large number of mechanoreceptors and smooth muscle cells called myofibroblasts (3).

Fascial techniques aim to release such tensions, decrease pain and restore function. The proposed mechanism for fascial techniques is based on various studies that looked at the plastic, viscoelastic and piezoelectric properties of connective tissue (4).

Several studies and clinical trials have shown that Myofascial treatment is effective in reducing myofascial pain (5,6) , increasing range of motion (7), improving functional disability and pressure pain threshold (8,9), and getting changes in both deep fascial motion and muscle stiffness, measured by elastography(10). There are two different Miofascial therapies: Myofascial Release and Myofascial Induction.(11) Myofascial induction procedures form part of the commonly used spectrum of manual therapy maneuvers in clinical practice and are targeted at myofascial areas compromised by restriction (12). As Pilat (2014)(3) has explained, the term 'Induction' relates to the correction of movement facilitation, and not a passive stretching of the fascial system. The intrafascial presence of myofibroblasts may alter their stiffness(13). Myofibroblasts are reparative connective tissue cells that contribute to the reconstruction of injured tissue by secreting new extracellular matrix and by exerting high contractile force(14). A positive correlation between myofibroblast density and contractile response was found(15). Tension of myofascial tissue is actively regulated by myofibroblasts with the potential to impact active musculoskeletal dynamics(15).

The plantar fascia is a thick fibrous connective tissue which originates at the medial tuberosity of the calcaneus and inserts into the proximal phalanges(12). Thickness of the plantar fascia in normal and injured patients does not vary between men and women(16). Also, it plays an important role in balance during the various phases of gait(17). Plantar fasciitis is a common condition and can occur as a single occurrence or repeatedly throughout life(17). Even with proper treatment some fasciitis take a year to improve and 20 percent require more treatment time(18).

Myofascial release in the management of plantar heel pain has been shown more reduction in pain and functional disability in a clinical trial(8). However, no research examining the effect of Fascial techniques on footprint and bipodal static balance was found.

Tactile stimulation improves postural control, as demonstrated by a comparative study of three different types of foot sole massage.(19) Therefore any Myofascial technique on the sole of the foot must be compared with a tactile stimulus to demonstrate the effect on balance and plantar footprint. To initiate the study of the potential effects, it is necessary to investigate its effects in asymptomatic subjects who do not have any process of sensitization(20).

The aim of this study is to check the effects of the pressure and traction technique, compared to a tactile stimulus on balance and plantar footprint variables in asymptomatic subjects. Our hypothesis is that after pressure and traction technique more surface and less plantar pressures will be in footprint and improve of balance will be seen at stabilometry variables.

Methods

2.1. Subjects

Forty healthy subjects (28 females and 12 males) were recruited for a simple blind study. The demographic data of the study participants were as follows: 39.42±10.41 years old, 167.65±8.39 cm height, and 67.72±9.11 kg weight. All demographic data are shown in Table 1. The

Ethics Committee of the Rey Juan Carlos University approved the study, number authorization 2111201814518, and all participants gave their written informed consent before participating. Number Ethical standards in human experimentation contained in the World Medical Association Declaration of Helsinki, the Council of Europe Convention on Human Rights and Biomedicine, the UNESCO Universal Declaration on the Human Genome and Human Rights, and those of the relevant national bodies and institutions were observed at all times. The protocol registration number is ID: NCT03997955.

A sample size calculation was carried out by the difference between 2 independent groups by the software pf G*Power 3.1.9.2 (G*Power©; Dusseldorf University; Germany) considering the difference (post – pre intervention) of the X displacement with open eyes (mean ± SD mm) stabilometry outcome measurement of a pilot study (n = 10) with 2 groups, 5 subjects from the experimental group (8.56 ± 5.62 mm) and 5 subjects from the control group (4.43 ± 2.17 mm)(22). Furthermore, a 2-tailed hypothesis test, an effect size of 1.07, an α error probability of 0.05, a power (1-β error probability) of 0.80 and an allocation ratio (N2/N1) of 1 were applied for the sample size calculation. Thus, a sample size of 30 subjects, divided into 15 participants for the experimental group and 15 participants for the control group, was calculated. Regarding the possible 30% loss to follow-up, 40 subjects, divided into experimental (n = 20) and control (N = 20) groups, were recruited for the total sample size.

All subjects were randomly distributed in two different groups: control group, and experimental group. Inclusion criteria included: healthy individuals with no pain(23). Exclusion criteria included: previous lower extremities surgery; history of lower extremities injury with residual symptoms (pain, "giving-away" sensations) within the last year; evidence of a leg-length discrepancy (difference in distance from the anterior superior iliac spine to the superior surface of the most prominent aspect of the medial malleolus) of more than 1 cm; and evidence of balance deficits (determined by oral questionnaire regarding falls)(23).

2.2. Procedures.

First, a clinician with ten years of experience performed a baseline balance evaluation to confirm the inclusion and exclusion criteria of each subject using the Balance Evaluation Systems test (BESTest)(24). All subjects had at least 15 degrees of ankle dorsiflexion(25)(26).

Participants were then randomly divided into two groups: experimental group or control group by a random number table provided by the clinician. Then, we measured footprint and stabilometry previous intervention. The clinician who performed the post-test evaluation had 10 years of experience in the use of the platform. Foot plantar pressure and surface area of static footprints were measured during bipodal standing. Stabilometry assessment was used and subjects were instructed to stand barefoot on the force platform (27), participants were instructed to remain in a relaxed standing posture with feet shoulder-width apart and positioned at 30º away from the midline (28). During all the examinations, the upper limbs were placed in a relaxed position along the body (29). The subjects were instructed to stand as still as possible for 30 s, with their eyes open (EO), while concentrating on a point at eye level 2-m away (23) or with their eyes closed (EC) (27). The order of eyes closed or open were randomized by a table too. The digital portable pressure sensor platform (Medicapteurs, Balma, France) was used (27)(30)(31). The technical specifications of the pressure platform are shown in the Table 2. Pressure sensor measurements from the platform were accurate to the nearest 0.001 kg/cm2. Before each use, auto-calibration was performed.

The experimental group received a pressure and traction technique to the plantar fascia, for longitudinal fascial restraints, as proposed by Pilat(3), applied by a clinician with 8 years of experience. The control group received a tactile stimulation, consisted in contact with the same position as experimental group technique to the plantar fascia, but without any pressure additional, only contact with the skin, and without any longitudinal traction of the fascia. Every group received 5 minutes treatment on each foot. The duration, position, and therapist were the same for both treatments.(32) The hands position of both groups can be seen at Figure 1.

Both groups repeated the measurement of static footprint and stabilometry after the intervention.

2.3. Measures.

Stabilometry was measured by displacement of the center of pressures in X and Y with eyes open and closed (27), center of pressure (COP) with eyes open and closed, COP area with eyes open and closed, COP antero-posterior (a-p) and medio-lateral (m-lat) directions with eyes open and closed, and COP speed (23). Two trials were recorded for each condition (27)(29)(23) and the order of the conditions was randomized across subjects, eyes open and eyes closed (27). Foot plantar pressure and surface area of two static footprints were measured during bipodal standing. Static plantar pressure was evaluated by means of maximum pressure, medium pressure and surface area of each aspect of the foot (rear foot, midfoot, and fore foot).

3.2. Statistical Analysis

All data were explored for normality using the Shapiro Wilks test, and data were considered normally distributed if $p > 0.05$. Descriptive statistical analysis was performed using mean ± SD and a 95% confidence interval.

The Mann–Whitney U test was performed to examine differences in non-parametric variables. Student's t-test two tailed was used for parametric variables. A p-value < 0.05 with a confidence interval of 95% was considered statistically significant for all tests (SPSS for Windows, version 20.0; SPSS Inc., Chicago, Illinois, USA).

Figure1. The hands position at experimental and control group.

4. Results

Twenty-four of thirty-eight variables were not normally distributed and therefore non-parametric statistics were used ($p < 0.05$). There were no significant differences between groups at baseline, before therapy (Table 3). There were significant differences between groups after therapy in balance variables: surface eyes closed, and x displacement with eyes open (Table 4).At Figure 2 it could be seen the stabilometry for a two representative subjects for each group.

Table 1. Socio-demographic characteristics of the sample population.

Variable Total (N = 20 +20)	**Total Group Mean SD (CI 95%)**	**Control Group Media ± SD (IC 95%)**	**Experimental Group Media ± SD (IC 95%)**	***p* value ***
Age (years)	39.42±10.41 (36.19-42.65)	40.05± 10.22 (35.56-44.53)	38.80± 10.83 (34.05-43.54)	0.709
Weight (Kg)	67.72±9.11 (64.89-70.55)	67.20± 10.40 (62.64-71.75)	68.25 ± 7.86 (64.80-71.69)	0.720
Height (cm)	167.65±8.39	168.90± 7.80	166.40 ± 8.96	0.352

	(165.04-170.25)	(165.47-172.32)	(162.47-170.32)	
BMI (Kg/m^2)	24.09±2.69 (23.25-24.93)	23.45±2.32 (22.43-24.47)	24.72±2.94 (23.43-26.02)	0.137
Size of shoe	39.68±2.20 (39.00-40.36)	40.07 ± 2.30 (39.06-41.08)	39.30 ± 2.07 (38.39-40.20)	0.270

Abbreviations: Kg, Kilograms; cm, centimeters; BMI, Body Mass Index; SD, standard deviation; CI 95%, confidence interval 95% . In all the analyses, $p < 0.05$ (with a 95% confidence interval) was considered statistically significant. P-values are from Independent student t-test *.

Table 2. Technical Specifications of the Pressure Platform

Specification	**Description**
Size (length x width x height)	530 x 600 x 45 mm
Thickness	4 mm
Active surface	400 x 400 mm
Weight	6.8 kg
Sensors	Calibrated resistive
Sensor	8 x 8 mm
Sensor thickness	0.15 mm
No. of sensors	2,304 (48 x 48)
Permissible temperature	-40°C to 85°C
Sensor pressure (minimum/maximum)	0.4 N/m2 (0.0004 kPa)/100 N/m2 (0.1 kPa)
Type of PC interface/platform	USB
Supply	USB cable
Data acquisition frequency	200 images/s
Vertical force recording	60 Hz
Operating system required	Windows XP, Vista, or 7

Table 3. Stabilometry and static footprints variables before bilateral myofascial induction and before control.

VARIABLE	**Control Group** PRETEST VALUES (n= 20) Mean ± SD (CI 95%)	**Experimental Group** PRETEST VALUES (n= 20) Mean ± SD (CI 95%)	*p* value
STATIC VARIABLES			
REAR FOOT MAXIMUM PRESSURE (K Pa)	101.26±17,25 (84.01-118.51)	98.61±20,30 (78.31-118.91)	0.658*
REAR FOOT MEDIUM PRESSURE (K Pa)	41.22±7.32 (33.9-48.54)	39.91±6.46 (33.45-46.37)	0.551*
REAR FOOT SURFACE (cm^2)	92.70±13.80 (78.90-106.5)	91.92±10,02 (81.9-101.94)	0.840*
MIDFOOT MAXIMUM PRESSURE	20.11±19.42	20.37±17.46	1.000**

(K Pa)	(0.69-39.53)	(2.91-37.83)	
MIDFOOT MEDIUM PRESSURE (K Pa)	16.84±28.52 (11.68-45.36)	8.88±7.25 (1.63-16.13)	0.925**
MIDFOOT SURFACE (cm^2)	26.27±26.30 (-0.03-52.57)	24.67±26.53 (-1.86-51.2)	0.583**
FORE FOOT MAXIMUM PRESSURE (K Pa)	72.48±13.06 (59.42-85.54)	70.66±14.63 (56.03-85.29)	0.681*
FORE FOOT MEDIUM PRESSURE (K Pa)	27.08±4.54 (22.54-31.62)	27.41±5.58 (21.83-32.99)	0.841*
FORE FOOT SURFACE (cm^2)	101.32±19.15 (82.17-120.47)	98.34±19.76 (78.58-118.1)	0.631*
STABILOMETRY VARIABLES			
X DISPLACEMENT EYES OPEN (mm)	7.32±4.58 (2.74-11.9)	5.86±4.66 (1.2-10.52)	0.398**
Y DISPLACEMENT EYES OPEN (mm)	14.26±11.93 (2.33-26.19)	14.03±10.24 (3.79-24.27)	0.904**
SURFACE EYES OPEN(mm^2)	11.89±6.34 (5.55-18.23)	14.56±16.07 (-1.51-30.63)	0.925**
MEDIUM SPEED OF THE LATEROLATERAL DISPLACEMENT. EYES OPEN (mm/s)	0.96±0.26 (0.7-1.22)	1.03±0.39 (0.64-1.42)	0.544*
MEDIUM SPEED OF THE ANTEROPOSTERIOR DISPLACEMENT. EYES OPEN (mm/s)	0.85±0.23 (0.62-1.08)	0.92±0.47 (0.45-1.39)	0.883**
X DISPLACEMENT EYES CLOSED (mm)	7.48±4.11 (3.31-11.59)	5.43±4.75 (0.68-10.18)	0.091**
Y DISPLACEMENT EYES CLOSED (mm)	12.41±12.10 (0.31-24.51)	12.36±9.56 (2.8-21.92)	0.640**
SURFACE EYES CLOSED (mm^2)	31.95±22.35 (9.6-54.3)	27.72±24.97 (2.75-52.69)	0.314**
MEDIUM SPEED OF THE LATEROLATERAL DISPLACEMENT. EYES CLOSED (mm/s)	1.23±0.42 (0.81-1.65)	1.24±0.48 (0.76-1.72)	0.989**
MEDIUM SPEED OF THE ANTEROPOSTERIOR DISPLACEMENT. EYES CLOSED (mm/s)	1.35±0.60 (0.75-1.95)	1.55±1.44 (0.11-2.99)	0.738**

Abbreviation: Kg (Kilograms); cm (centimeters), cm^2 (centimeters^2), SD (standard deviation), CI 95% (confidence interval 95%), * T-student 2-tailed, **Mann–Whitney U test value $p < 0.05$.

Table 4. Stabilometry and static footprints variables after bilateral myofascial induction and after control.

VARIABLE	**Control Group**	**Experimental**	*p* value

	POSTTEST VALUES (n= 20) Mean ± SD (CI 95%)	**Group** POSTTEST VALUES (n= 20) Mean ± SD (CI 95%)	
STATIC VARIABLES			
REAR FOOT MAXIMUM PRESSURE (K Pa)	102.25±20.47 (81.78-122.72)	99.04±20.87 (78.17-119.91)	0.626*
REAR FOOT MEDIUM PRESSURE (K Pa)	38.84±7.16 (31.68-46)	38.37±6.05 (44.42-32.32)	0.820**
REAR FOOT SURFACE (cm^2)	93.82±10.94 (104.76-82.88)	92.42±10.50 (81.92-102.92)	0.684*
MIDFOOT MAXIMUM PRESSURE (K Pa)	18.59±20.75 (-2.16-39.34)	18.27±13.84 (4.43-32.11)	0.758**
MIDFOOT MEDIUM PRESSURE (K Pa)	8.66±7.87 (0.79-16.53)	9.29±6.86 (2.43-16.15)	0.820**
MIDFOOT SURFACE (cm^2)	25.73±26.90 (-1.17-52.63)	24.60±20.28 (4.32-44.88)	0.862**
FORE FOOT MAXIMUM PRESSURE (K Pa)	69.79±9.77 (60.02-79.56)	74.82±11.37 (63.45-86.19)	0.142*
FORE FOOT MEDIUM PRESSURE (K Pa)	26.30±4.56 (21.74-30.86)	28.20±3.70 (24.5-31.9)	0.157*
FORE FOOT SURFACE (cm^2)	103.47±15.82 (87.65-119.22)	103.37±17.44 (85.93-120.81)	0.985*
STABILOMETRY VARIABLES			
X DISPLACEMENT EYES OPEN (mm)	8.21±4.10 (4.11-12.32)	5.03±3.72 (1.31-8.75)	0.014*
Y DISPLACEMENT EYES OPEN (mm)	13.97±11.43 (2.54-25.4)	12.93±9.58 (3.35-22.51)	0.925**
SURFACE EYES OPEN(mm^2)	9.96±6.01 (3.95-15.97)	15.33±18.58 (-3.25-33.91)	0.718**
MEDIUM SPEED OF THE LATEROLATERAL DISPLACEMENT. EYES OPEN (mm/s)	1.29±0.86 (0.43-2.15)	1.09±0.44 (0.65-1.53)	0.820**
MEDIUM SPEED OF THE ANTEROPOSTERIOR DISPLACEMENT. EYES OPEN (mm/s)	0.90±0.30 (0.6-1.2)	1.04±0.43 (0.61-1.47)	0.192**
X DISPLACEMENT EYES CLOSED (mm)	7.66±4.49 (3.17-12.15)	5.92±4.48 (1.44-10.4)	0.228*
Y DISPLACEMENT EYES CLOSED (mm)	11.55±10.49 (1.06-22.04)	11.64±8.55 (3.09-20.19)	0.512**
SURFACE EYES CLOSED (mm^2)	36.73±23.46 (13.27-60.19)	22.10±23.51 (-1.41-45.61)	0.046**
MEDIUM SPEED OF THE LATEROLATERAL DISPLACEMENT. EYES CLOSED (mm/s)	1.31±0.86 (0.45-2.17)	1.17±0.44 (0.73-1.61)	0.947**

MEDIUM SPEED OF THE ANTEROPOSTERIOR DISPLACEMENT. EYES CLOSED (mm/s)	1.49±1.22 (0.27-2.71)	1.32±0.59 (0.73-1.91)	0.925**

Abbreviation: Kg (Kilograms); cm (centimeters), cm^2 (centimeters^2), SD (standard deviation), CI 95% (confidence interval 95%), * T-student 2-tailed, **Mann–Whitney U test value $p < 0.05$.

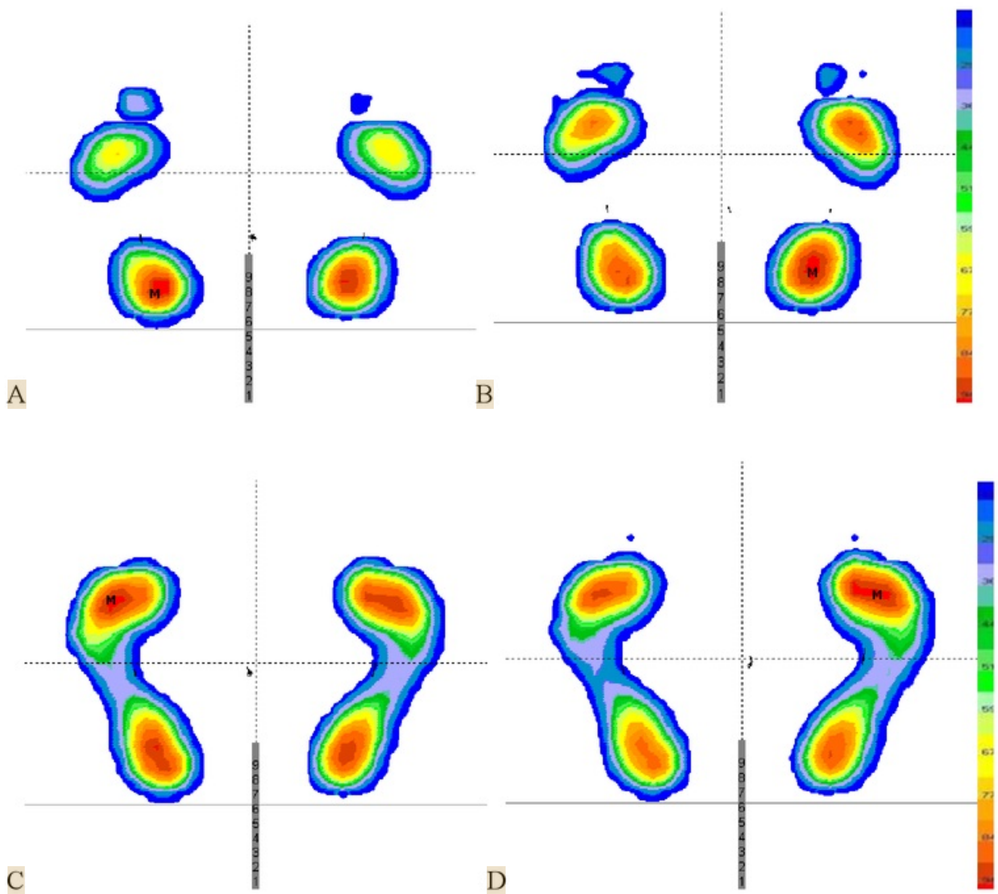

Fig. 2 Distribution of pressure and stabilometry for a representative subject with eyes closed before pressure and traction technique (A) and a distribution on pressure and stabilometry for a representative subject with eyes closed after pressure and traction technique (B) Distribution of pressure and stabilometry for a representative subject with eyes closed before tactile stimulus (C) Distribution of pressure and stabilometry for a representative subject with eyes closed after tactile stimulus (D) The black lines show the COP for each group and condition. The scale on the right indicates pressure (g/cm2).

5. Discussion

This study uses a pressure platform to measure the immediate effects of the manual pressure and traction technique of the plantar fascia on the static footprint and stabilometry compared to an active control group. After technique the experimental group improved the stabilometry variables, specifically, surface with eyes closed and x displacement with eyes open with significant differences. The static footprint variables have not shown differences after the technique compared to the control group.

Reduce of surface with eyes closed and x displacement with eyes open after treatment in experimental group implies several conclusions that we can develop from this finding. In the first place, the control technique presents contact with the skin, which discards the findings of the improvement of postural control due to tactile stimulation, and verify the deep stimulus generated by the pressure and traction technique. The fascial system is highly innervated and has dense population of mechanoreceptors: Golgi receptors in muscle-tendon unit, Pacinian corpuscle, free terminations of sensitive fibers ,Type III myelinated and IV amyelinated, and Ruffini organ (3). Ruffini organ respond to slow impulses and sustained pressures, especially by tangent forces made in transverse direction(33), This tangential force to stimulate Ruffini organ, differ between both groups and to which we attribute the improvement of proprioception after technique. The proprioceptive function of the fascia has been enunciated by different authors of histological studies on the thoracolumbar fascia, but they have not been able to be affirmed (33),(34). Fascial tissues demonstrate an important proprioceptive function thanks to this clinical trial.

Other difference between study technique and control technique was the manually follow the subsequent movement of the fascia that occurs after pressure and traction, called by some authors induction (11). The subsequent movement of the fascia is create by myofibroblasts (33), documented in fibrotic and in normal fasciae(13), suppose that the contraction of these smooth muscle fibers can have an auxiliary function in the maintenance of the tension necessary for a correct maintenance of the static and balance. So, we think that correct tension of the fascia should be related with correct balance and posture. In this sense we find the study of Petrofsky and Lee (35) made after checking that reduction of balance of increased plantar fascia elasticity at ovulation during the menstrual cycle. Our study demonstrates that returning adequate tension to the fascia with myofascial technique can lead to improvements in balance. So, during ovulation, and pathologies with altered tension in the plantar fascia and fascia such as Palmar fibromatosis(36), Morbus Ledderhose(36), hypertrophic scars(36), fasciitis(37) and flat foot (37) myofascial technique may be applied to returning adequate tension to the fascia and improve balance.

The results of this trial indicate the technique in pathologies with altered proprioception, such as ankle sprain, where the addition has been shown improvement in pain and function(38). In our opinion, it must be included previous proprioception exercises due to the stimulation of the mechanoreceptors that involves the realization of myofascial induction.

6. Study Limitations.

Our study answers the research question and uses this active control to verify the effect of pressure and traction beyond touch. However subsequent studies are necessary with validated sham as a control to verify the full effect of the pressure and traction technique.

7. Conclusions.

Manual pressure and traction technique of the plantar fascia improved the stabilometry variables, surface with eyes closed and x displacement with eyes open.

The static footprint variables have not shown differences after the technique compared to the control of tactile stimulation.

The protocol registration number is ID: NCT03997955 and is verifiable at clinicaltrials.gov

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